U.S.A. 14

BOSTON NUMBER

Mosquito News

Published Quarterly

by the

AMERICAN MOSQUITO CONTROL ASSOCIATION, INC.

VOLUME 20 JUNE, 1960 NUMBER 2

CONTENTS

PAPERS AND PROCEEDINGS OF ANNUAL MEETING—PART 1 PAGE

Panel on Eastern Encephalitis.....R. O. Hayes, Moderator 83
Enzootic Eastern Encephalitis Activity in Massachusetts
R. O. Hayes, L. C. LaMotte and A. D. Hess 85
Some Evidence of Local Origin of EEE Virus in Florida.....F. G. Favorite 87
Current Knowledge of Eastern Encephalitis in Maryland.....W. E. Bickley and R. J. Byrne 93
Mosquito Surveillance and Abatement at Fort Dix, New Jersey During the Eastern Equine Encephalitis Outbreak of 1959.....M. B. Flemings, I. H. Waller and H. Estes 94
Some Factors Influencing Larval Populations of *Culex tarsalis* and Western Equine Encephalitis in Utah.....J. E. Graham, I. E. Bradley and G. C. Collett 100
Safety Procedures in Mosquito Control Operations.....F. C. Wray 104
Airplane Application of Granular Paris Green Mosquito Larvicide
A. J. Rogers and C. B. Rathburn, Jr. 105
Past, Present and Future in Insecticide-Resistance of Mosquitoes.....A. W. A. Brown 110
Susceptibility Levels of Some *Aedes aegypti* (Linn.) Larvae to DDT and Dieldrin
B. R. Evans, J. E. Porter, G. Kozuchi and E. J. Fink 116
Cross-Resistance Characteristics of a Malathion-Tolerant Strain Developed in *Aedes aegypti*
A. W. A. Brown and Z. H. Abedi 118
More About *Culex*.....F. C. Wray 125
Microbiology and Mosquito Control.....Marshall Laird 127
The Control of Mosquitoes by Pathogenic Microorganisms.....W. R. Kellen 133

ARTICLES

Behavior Preceding Migration in the Salt-Marsh Mosquito, *Aedes taeniorhynchus* (Wiedemann)
J. S. Haeger 136
The Dispersal of *Aedes taeniorhynchus* III. Study Methods for Migratory Exodus
M. W. Provost 148
Observations on the Breeding Habitats of Some *Culicoides* and Other Heleidae in the Panama Canal Zone (Diptera).....S. G. Breeland 161
Mosquito Larvicide Field Tests in Irrigated Pastures of the San Joaquin Valley, California
L. L. Lewallen and C. M. Gjullin 168
Observations on the Biology of *Eucorethra underwoodi* Underwood in Passaic County, New Jersey and Bristol County, Massachusetts.....R. W. Lake 171
Mammalian Burrows and Vegetation as Summer Resting Sites of the Mosquitoes *Culex tarsalis* and *Anopheles freeborni*.....R. F. Harwood and J. E. Halfhill 174
Effect of Temperature on Rate of Release of Toxicants from Granules and on Breakdown of Certain Insecticides in Water.....Mir S. Mulla and H. Axelrod 178
Laboratory Studies of Residual Toxic Effects of Malathion Granules on *Culex pipiens quinquefasciatus* Say Larvae.....L. Rai and L. L. Lewallen 184

Continued on p. XIX

Annual Meeting, January 31–February 2, 1961, Disneyland, California

MOSQUITO NEWS

Official Publication of the American Mosquito Control Association, Inc.

EDITORIAL STAFF

DONALD L. COLLINS, *Editor*, New York State Education Bldg., Albany 1, New York

R. D. GLASGOW, *Consulting Editor*, New York State Education Bldg., Albany 1, New York

MRS. MARGARET G. SLATER, *Assistant to Editor*, New York State Education Bldg., Albany 1, New York

HELEN SOLLERS, *Associate Editor* (Bibliography), Plant Pest Control Div., Agric. Res. Service, U. S. Dept. of Agriculture, Washington 25, D. C.

MRS. HELEN LOUISE DURKEE, *Associate Editor* (Reviews and Abstracts), 113 Sonora Avenue, Danville, California

AUSTIN W. MORRILL, JR., *Associate Editor* (News and Notes), DD-111, District Public Works Office, Hq. 12th Naval District, San Bruno, California

W. C. MCDUFFIE, *Associate Editor* (Articles), USDA, Entomology Research Division, Plant Industry Station, Beltsville, Maryland

---

F. P. CREADON, Advertising Manager, Desplaines Valley Mosquito Abatement Dist., 8130 Ogden Ave., Lyons, Ill.

T. G. Raley, Executive Secretary, P. O. Box 278, Selma, Calif.

L. W. SMITH, Treasurer, Parsonage Road, Metuchen, N. J.

WILLIAM M. THOM, Asst. Treasurer, Parsonage Road, Metuchen, N. J.

Published by
AMERICAN MOSQUITO CONTROL ASSOCIATION, INC.

Printed by
Boyd Printing Company, Inc., Albany, N. Y.

A quarterly journal published on the 20th of March, June, September and December. Devoted to the improvement and the sound extension of mosquito control and related work as a vital public health service.

SUBSCRIPTION RATES

$5.00 per Year (U. S. money), Single Copies, $1.75
Mailed without charge to members of the Association.

MEMBERSHIP DUES—$5.00

PUBLICATION OFFICE: American Mosquito Control Association, Inc., Room 461, State Education Bldg., Albany 1, N. Y. GENERAL OFFICE: P. O. Box 278, Selma, Calif. BUSINESS OFFICE: P. O. Box 346, Metuchen, N. J. *Second class postage* paid at Albany, N. Y.

BUSINESS COMMUNICATIONS

Communications relating to editorial matters and manuscripts submitted for publication in MOSQUITO NEWS should be addressed to Donald L. Collins, Editor, MOSQUITO NEWS, New York State Museum, Albany 1, New York.

Communications relating to advertising space should be addressed to F. P. Creadon, Advertising Manager, Desplaines Valley Mosquito Abatement Dist., 8130 Ogden Ave., Lyons, Ill.

Communications relating to subscriptions to MOSQUITO NEWS, Membership in the American Mosquito Control Association, and other association matters should be addressed to T. G. Raley, Executive Secretary, American Mosquito Control Association, P. O. Box 278, Selma, Calif. Changes of address should reach the Secretary before the first of the month of publication.

Copyright 1960 by
THE AMERICAN MOSQUITO CONTROL ASSOCIATION, INC.

PAPERS AND PROCEEDINGS OF THE 16th ANNUAL MEETING

of the

AMERICAN MOSQUITO CONTROL ASSOCIATION

Held Jointly with the Northeastern Mosquito Control Association
Boston, Massachusetts, March 27–30, 1960

Part I*

PANEL ON EASTERN ENCEPHALITIS

Synopsis by RICHARD O. HAYES (Moderator)
Taunton Field Station, Taunton, Mass.

The moderator introduced the panel members (see Program, *Mosquito News* 20:1) and presented a brief history of eastern encephalitis (EE). EE virus infection is one of three arthropod-borne encephalitides which affect man in the United States. The virus attacks the central nervous system and the resulting symptoms include fever, drowsiness, convulsions, and coma. Approximately 70 percent of the clinical cases are fatal. Eastern encephalitis is found in the United States mainly along the eastern seaboard from Massachusetts to Texas on the Gulf of Mexico. In 1959 EE was found in at least six eastern states. During 1959 the first outbreak among humans in New Jersey occurred, and the first record was made of the virus affecting ducklings on Long Island, New York.

VIRUS VECTOR RESEARCH

ROY W. CHAMBERLAIN

The speaker pointed out that EE is primarily a bird disease and that the enzootic (wild animal) vector must be a bird feeder, probably feeds at night, and must be susceptible to infection and capable of transmission. *Aedes* and *Psorophora* do not generally fit the requirements, and *Mansonia perturbans* is usually not abundant enough late in the summer to be involved in the enzootic cycle. Twenty-two of the thirty isolations of EE from naturally infected mosquitoes incriminate *Culiseta melanura* as the enzootic vector among the wild bird hosts. Although EE isolations have been made from *Culex salinarius,* laboratory experiments indicate it is not a likely vector. *Anopheles* species are also poor vectors in the laboratory. Eleven of 15 isolations of western encephalitis from mosquitoes in the Eastern United States were obtained from *Culiseta melanura.*

The criteria for an outbreak among

* The Proceedings papers included in this issue of *Mosquito News* comprise all the papers that had been received in final form for publication on the date of going to press, May 13, 1960. It is planned to publish in the September number papers which have not yet been received and those which had to be held for revision, correction of illustrations, and similar reasons.

humans (epidemic cycle) include a high mosquito population, a high infection rate in wild birds, and a non-immune horse or high human population at a given time. It was pointed out that *Aedes vexans* might have been involved as the vector species in the 1938 Massachusetts epidemic and that *A. sollicitans* might have been the epidemic vector in the 1959 New Jersey outbreak.

THE IMPORTANCE OF BIRDS AND BIRD MOVEMENT

DONALD D. STAMM

Studies to determine whether or not birds are involved in dissemination of EE virus from fresh water swamp habitats are being conducted. Bird census and blood sampling methods of the study were described. Recapture and rebleeding of individual birds has given information which will be evaluated to determine whether or not the amount of virus transmission and the number of birds present correlate directly. Up to 500 blood samples have been taken during a 12-day period, and viremias in as much as 5 percent of the birds have been encountered. Dr. Stamm believes that encephalitis transmission is closely associated with high bird densities—such as occur in swamps. Thus the danger of transmission of EE to man increases when high bird population densities become established, or build up periodically, near human habitats.

CONNECTICUT STUDIES ON EASTERN ENCEPHALITIS

ROBERT C. WALLIS

Since no human cases of EE have been reported from Connecticut, the studies there initially involved transmission to pheasants being reared on game farms. It was concluded that initial transmission to pheasants is mosquito-borne, but that most of the pheasants are infected by feather picking and cannibalism. Recently a search for the vector transmitting EE to horses in the state resulted in the isolation of EE from *Aedes vexans,* and it is believed the species is involved there in spreading the disease from birds to horses.

Laboratory evidence indicates that non-blood-sucking insect larvae may be involved in spreading the virus among the wild bird population.

1959 NEW JERSEY OUTBREAK

DANIEL M. JOBBINS

Human cases of EE in New Jersey occurred for the first time during 1959. There were 33 confirmed cases; of these, 21 died; 2 individuals recovered from remarkably mild clinical cases. The cases occurred between August 16 and October 15. Most of the cases occurred in the southern part of the state within a 60-mile area along the east coast of the state—especially in communities situated adjacent to woodlands or swamps. Horse cases (56) and pheasant outbreaks (16) also occurred, and even though there are many more pheasant farms in the north than in the south, most of the pheasant infections occurred in south New Jersey—as did the horse cases. Virus isolations were made from *Culex restuans,* and from two other mosquito pools which were composed of several mosquito species, or of unidentified specimens. EE virus was also isolated from two species of wild birds: House Sparrow, and Myrtle warbler.

ENZOOTIC VIRUS ACTIVITY IN MASSACHUSETTS

RICHARD O. HAYES

Outbreaks of eastern encephalitis (EE) in Massachusetts which have affected humans and horses occurred during 1938, 1955, and 1956.

To obtain detailed information regarding the enzootic virus activity, four chicken flocks were established in Raynham, Massachusetts to serve as sentinels of virus activity during 1959.

The results reveal that a considerable amount of virus activity occurred during 1959. It was a year in which no human or horse cases of EE occurred in Massachusetts, and by previous standards it was a year that would have been considered one during which no virus was present.

The high infection rate among the chickens located within a fresh-water swamp, Pine Swamp, was significantly different from the infection rates in the other three flocks. This difference substantiates the hypothesis that a fresh-water swamp, with suitable ecologic conditions, may serve as the enzootic focus for dispersion of EE virus, and that outbreaks of EE among man and horse in Massachusetts are contingent upon conditions favorable to the dispersion of the virus.

ENZOOTIC EASTERN ENCEPHALITIS ACTIVITY IN MASSACHUSETTS [1]

RICHARD O. HAYES,[2] LOUIS C. LAMOTTE,[2] AND A. D. HESS [2]

Outbreaks of eastern encephalitis (EE) in Massachusetts that have affected humans and horses occurred during 1938, 1955, and 1956. In the 1938 outbreak, 38 humans and 248 horses were stricken; 4 humans and 44 horses were infected in 1955; in 1956, there were 12 human and 41 horse cases (Feemster, 1938; Feemster *et al.,* 1958). This sporadic occurrence of human and equine outbreaks might suggest the absence of EE virus from Massachusetts during interepidemic periods, but both virus and antibodies for EE were detected in wild birds in 1953, when no human or equine cases were reported (Feemster *et al.,* 1958). Subsequent studies during 1957, 1958, and 1959 also revealed the presence of EE antibodies in juvenile wild birds and resident domestic chicken flocks, even though there was no evidence of clinical disease in humans or horses (Hayes *et al.,* in manuscript). Thus, it appears that EE virus remains active in enzootic foci in Massachusetts during interepidemic periods. The objective of the present study was to measure the level of EE virus activity in an enzootic swamp focus as compared with nearby upland habitats.

METHODS AND MATERIALS. EE virus transmission indices were obtained by maintaining a chicken flock of approximately 50 birds at each of the study sites near Taunton, Massachusetts, during the period of June 22 to October 16, 1959. The birds were kept in the type of standard sentinel shed described by Rainey *et al.* (1960). The chickens were about 11 weeks old when placed in the field. Pre-bleeding of a random sample from

[1] This investigation is part of a joint study on eastern encephalitis by the Communicable Disease Center, U. S. Public Health Service, and the Division of Communicable Diseases, Massachusetts Department of Public Health.

[2] From the Encephalitis Section, Technology Branch, Communicable Disease Center, Public Health Service, U. S. Department of Health, Education, and Welfare, Greeley, Colorado.

the same series indicated that none previously had been infected with EE virus. The birds were bled at intervals during the season, and the percent showing hemagglutination-inhibition antibodies (Casals and Brown, 1954) at the end of the season provided an index of EE transmission for each of the study sites. The blood was obtained from the wing veins of the chickens, and the specimens of serum were stored at — 65° C. until tested.

One sentinel flock was placed at each of four study sites. Site 1 was near the center of a large fresh-water swamp known as "Pine Swamp," in which there was heavy breeding of *Culiseta melanura,* the primary enzootic vector of EE. The dominant trees in the swamp are red maple (*Acer rubrum*) and white cedar (*Chamaecyparis thyoides*). Sites 2, 3, and 4 were east of Pine Swamp, and no other swamp was closer to each of the three sites than was Pine Swamp. Site 2 was located 0.1 mile from the edge of Pine Swamp, and the dominant trees were black spruce (*Picea mariana*) and white pine (*Pinus strobus*). Site 3 was located among black cherry (*Prunus serotina*) and red maple (*Acer rubrum*) trees 0.4 mile from the swamp. Site 4 was 2.0 miles from Pine Swamp in a hillside habitat characterized by black oak (*Quercus velutina*), red maple (*Acer rubrum*), and white pine (*Pinus strobus*).

RESULTS. The results of hemagglutination-inhibition antibody (HAI) tests with sera collected from each of the sentinel flocks at the end of the season are summarized in Table 1. The transmission rates (HAI antibody rates) at sites 2, 3, and 4 were all about the same (35, 36, and 35 percent, respectively), but the rate at site 1 was 65 percent—almost twice as high as at the other sites. This difference is highly significant when analyzed by fourfold contingency table tests (Mainland *et al.,* 1956). Since eastern and western viruses both belong to Group A and may cross react in HAI tests, the results can only be taken as evidence that HAI antibodies against Group A antigens were present. However, mouse neutralization tests with a selected sample of the positives indicated that most of the immunity was undoubtedly due to EE rather than WE (western encephalitis) infection.

TABLE 1.—HAI antibody rates in chicken sentinel flocks maintained in Pine Swamp area, Taunton, Massachusetts, during the 1959 transmission season

Flock location	Miles from swamp	No. sera tested	Percent with EE antibodies
Site 1	0	37	65
Site 2	0.1	37	35
Site 3	0.4	42	36
Site 4	2.0	43	35

DISCUSSION. No human or equine cases of encephalitis were reported from Massachusetts during 1959. The results of these studies show conclusively, therefore, that high levels of virus activity may occur in enzootic swamp foci during non-epidemic years. They also indicate that this activity may extend considerable distances beyond the enzootic foci into inhabited areas without evidence of clinical disease in the human or equine populations. Long term observations are being continued in the Pine Swamp area to determine the consistency of these patterns of EE transmission and the various ecological factors that may influence them.

SUMMARY. From June 22 to October 16, 1959, four flocks of sentinel chickens were maintained near Taunton, Massachusetts, in the vicinity of a swamp which produced large numbers of *Culiseta melanura.* Serum specimens collected from the sentinel chickens at the end of the season and tested for hemagglutination-inhibition antibodies against EE antigen revealed a high transmission rate (65 percent positive) near the center of the swamp, and lower rates (about 35 percent positive) at the other sites located up to two miles from the edge of the swamp. Since no human or equine cases of arthropod-borne encephalitis were reported during 1959, it appears that high levels of enzootic transmission may occur in Massachusetts without involving horses or humans.

References Cited

CASALS, J., and BROWN, L. V. 1954. Hemagglutination with arthropod-borne viruses. Jour. Expt. Med., 99:429–49.

FEEMSTER, R. F. 1938. Outbreak of encephalitis in man due to the eastern virus of equine encephalomyelitis. Amer. Jour. Publ. Hlth., 28: 1403–10.

FEEMSTER, R. F., WHEELER, R. E., DANIELS, J. B., ROSE, H. D., SCHAEFFER, M., KISSLING, R. E., HAYES, R. O., ALEXANDER, E. R., and MURRAY, W. A. 1958. Field and laboratory studies on equine encephalitis. New England Jour. Med., 259:107–13.

HAYES, R. O., DANIELS, J. B., ANDERSON, K. S., PARSONS, M. A., LAMOTTE, L. C., and MAXFIELD, H. K. 1960. Detection of eastern encephalitis virus antibodies in wild and domestic birds in Massachusetts, 1957–1959. (In manuscript.)

MAINLAND, D., HERRERA, L., and SUTCLIFFE, M. I. 1956. Statistical tables for use with binomial samples-contingency tests, confidence limits, and sample size estimates. 83 pp. New York Univ. College Med., New York, N. Y.

RAINEY, M. B., WARREN, G. V., HESS, A. D., and BLACKMORE, J. S. 1960. A sentinel chicken shed and mosquito trap for use in encephalitis field studies. Unpubl. ms.

SOME EVIDENCE OF LOCAL ORIGIN OF EEE VIRUS IN FLORIDA [1]

FRANK G. FAVORITE [2]

Several epidemiologically distinct features of eastern equine encephalomyelitis (EEE) are observed repeatedly during endemic and epidemic periods; (see Table 1). Major voids in the knowledge of various aspects of the etiology persist. Some of these are: The vector of the virus during endemic periods; the location of the virus during the winter season in the United States; and the method of virus activation during favorable seasons in the United States. In other words, is the virus transmitted during endemic periods by only one or two species of mosquitoes; and further, is the virus removed completely in the winter from its summer location to be reintroduced the following spring or summer by migratory birds, or does it persist in an arthropod or other animal host in a latent or masked stage from year to year in the United States?

While none of these highly complex problems was approached specifically in the study reported upon here, the study was comprehensive. It involved collections of arthropods and bird bloods, virus isolation studies, serological studies of birds and ecological studies in Georgia, South Carolina, and central Florida during 1957 and 1958. The major emphasis was placed on central Florida, in the Orlando area, during the spring and early summer of 1958, and this report covers only that aspect.

Florida is considered an especially fertile area for studying EEE. The Florida peninsula serves as a point of departure and arrival for the migratory birds, primary reservoirs of EEE virus, to and from Cuba, Central and South America, and Mexico (7). Furthermore, the reported incidence of equine cases of disease during the past 5 years has exceeded the reported incidence in other states by a considerable margin. For example: In Florida during 1956 there were 107 cases, in 1957 there

[1] Study supported in part by The Army Surgeon General, R and D Contract Number 6–61–04–007.

[2] U. S. Army Environmental Health Laboratory, Army Chemical Center, Maryland. This paper represents a portion of a dissertation submitted to the Graduate Faculty of the University of Maryland in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

TABLE 1.—Repeated observations during endemic and epidemic periods of EEE in the United States

Endemic period	Epidemic period
Low to moderate rate of serum neutralizing antibody in wild birds (1, 2).	High rate of serum neutralizing antibody among wild birds late in period (1, 2).
Infrequent indications of circulating virus in wild birds (1, 2).	Relatively frequent isolations of virus from wild birds (1, 2).
Localization of inapparent disease in large wading birds (3).	Inapparent disease in a wide variety of wild birds (3).
Few equine cases and rare human cases (4).	Numerous equine cases and outbreaks of human cases (4).
Biological vector uncertain.	Biological vectors incriminated most frequently, *Culiseta melanura* (5, 6).

were 386, and in 1958 there were 94 cases (8). Yet with this indication of virus activity, never has the virus of EEE been isolated from mosquitoes taken in Florida even though numerous workers have attempted to do so. Most of these attempts have not been published, presumably because of the negative results obtained.

FIELD AND LABORATORY STUDIES

ARTHROPODS. Adult mosquito collections were made from March to July at 11 different sites within a 50-mile radius of Orlando, Florida. Most of the sites were located immediately adjacent to, or within fresh water cypress and oak swamps. Both standard and modified New Jersey light traps, fitted with live-catch containers, were used for collection. Collections were removed at midnight and dawn of each day throughout the study. Specimens were identified while alive, sealed in screw-cap vials, placed on dry ice and held for subsequent virus isolation attempts. Within a week the specimens were transferred to an electric freezer, maintained at –60° C. Suspensions of high suspect vectors such as *Culiseta melanura* (Coq.), *Mansonia perturbans* (Walker) and *Aedes sollicitans* (Walker) were inoculated intracerebrally into three-week-old Swiss white mice within 10 days of collection. Other species had a storage period of 10 to 30 days. Preparation of mosquitoes into a suspension for intracerebral inoculation into three-week-old mice followed standard procedures except that 20 percent normal rabbit serum (phosphate buffered to pH 7.6) was used as a diluent.

A total of 5611 adult, unengorged female mosquitoes were retained for virus isolation attempts. Of this total, representing 8 genera and 24 species, there were 215 specimens of *Culiseta melanura,* 154 specimens of *Mansonia perturbans* and 8 specimens of *Aedes sollicitans.*

None of the mosquito pools inoculated into mice produced any lethal pattern which could be perpetuated or isolated.

BIRDS. Birds were collected by using Japanese Mist Nets and by shooting. Blood was collected from birds by several different methods, as dictated by the size of the bird. Small birds were difficult to bleed from veins or by cardiac puncture. Bending the head backwards and snipping the throat with iris scissors and allowing the blood to spurt into a sterile vial proved convenient for small birds. Larger birds were bled from veins or by cardiac puncture using a small hypodermic needle and suitably sized syringe. Blood was immediately transferred into sterile vaccine bottles and placed in refrigeration. Where an adequate quantity of blood permitted, serum was removed and the residual blood was diluted with an equal volume of 20 percent normal rabbit serum. The blood was then frozen and held for virus isolation attempts. The serum was retained under refrigeration until serological studies

were performed. Frozen whole bloods were used both for virus isolation attempts and serological studies.

Three hundred and twenty birds, representing 44 species, were collected during the spring and early summer of 1958 in central Florida. Ninety-six specimens of serum or whole blood neutralized at least 1.5 logs of EEE virus. Four of these specimens also neutralized at least 1.5 logs of WEE virus, see Table 2.

Hemagglutination-inhibition (HI) test of whole bloods, reportedly satisfactory at some laboratories (10) gave equivocal results. HI test of 65 bird sera gave clear-cut results at a dilution of 1:20, using 8 units

TABLE 2.—Results of studies on birds collected in Florida, 1958

Species	Residence status (9)	Pos. EEE (WEE) *neut. test*[a] Total Coll.	EEE virus isolated
Water turkey	Perm.	1/4	0
Double-breasted cormorant	Perm.	0/1	0
Green heron	Perm.	0/2	0
Little blue heron	Perm.	1 (1)/2	0
American egret	Perm.	2/8	0
Snowy egret	Perm.	2/4	0
Osprey	Perm.	1 (1)/1	0
Bob-white	Perm.	1/3	0
Killdeer	Perm. & Winter	2/5	0
Spotted sandpiper	Winter	0/1	0
Ground dove	Perm. & Winter	0/3	0
Yellow-billed cuckoo	Summer	0/1	0
Chuck-will's widow	Summer	0/2	0
Red-headed woodpecker	Perm.	8/21	0
Red-bellied woodpecker	Perm.	4/12	0
Pileated woodpecker	Perm.	1/3	0
Red-cockaded woodpecker	Perm.	0/1	0
Yellow-shafted flicker	Perm.	0/4	0
Crested flycatcher	Summer	2/16	0
Eastern kingbird	Summer	0/6	0
Crow	Perm.	2/7	0
Bluejay	Perm.	2/7	0
Tufted titmouse	Perm.	1/4	1
Carolina wren	Perm.	0/5	1
Blue-gray gnatcatcher	Perm.	0/2	0
Bluebird	Perm. & Winter	6/16	1
Catbird	Perm. & Winter	1/2	0
Mockingbird	Perm.	2/4	0
Brown thrasher	Perm. & Winter	1/3	0
Loggerheaded shrike	Perm. & Winter	7/14	0
Yellow-throated warbler	Summer	0/1	0
Parula warbler	Perm. & Winter	0/3	0
Northern waterthrush	Winter	0/1	0
Blackpoll warbler	Winter	0/1	0
Meadowlark	Perm. & Winter	25 (2)/59	1
Red-wing blackbird	Perm. & Winter	3/16	0
Rusty blackbird (?)	Winter	2/6	1
Brewer's blackbird (?)	?	1/9	0
Boat-tailed grackle	Perm.	3/6	0
Summer tanager	Summer	1/1	0
Cardinal	Perm.	10/29	0
Towhee	Perm. & Winter	4/22	1
English sparrow	Perm.	0/1	0
Pine-woods sparrow	Perm.	0/1	0
Total		96 (4)/320	6

[a] Neutralized at least 1.5 logs of virus.

TABLE 3.—Comparison of EEE serum neutralization and hemagglutination-inhibition tests of 65 bird sera collected in Florida, 1958

Serum Neut. test	HI test	
	Positive [b]	Negative
Positive [a]	17	6
Negative	14	28
Total	65	

[a] Neutralized at least 1.5 logs of EEE virus.
[b] Inhibited hemagglutination at a dilution of 1:20 or greater using 8 units of antigen.

of antigen. Some specimens inhibited hemagglutination at dilutions as high as 1:160. A modification of the method of Clarke and Casals (11) was used. Table 3 shows the results of HI tests of 65 bird sera in comparison with the results of serum neutralization tests of the same sera.

Whole bloods and normal rabbit serum diluted bloods (from which most of the original serum had been removed) were inoculated intracerebrally into three-week-old mice for virus isolation attempts. Virus was isolated from six species of birds, three of which were collected on the same day from the same location. All six isolates were identified as EEE virus by serum neutralization tests, see Table 4. Hyperimmune serums to the viruses of EEE, WEE and SLE were prepared in rabbits. (Difficulty was experienced in maintaining a reasonably uniform infectivity titer with SLE virus, hence its homologous antiserum was unreliable in these tests.)

TABLE 4.—Identification of virus isolates obtained from birds collected in Florida, 1958

Blood source	Neutralization test results (Log LD_{50} of neutralization index)	
	EEE rabbit immune serum. (J–90B strain EEE virus*)	WEE rabbit immune serum. (L2–34a strain WEE virus*)
Rusty blackbird (?)	3.7	< 1.0
Meadowlark	3.2	1.0
Tufted titmouse	4.0	< 1.0
Carolina wren	3.0	< 1.0
Towhee	3.5	< 1.0
Bluebird	3.3	< 1.0

* Furnished by Dr. R. W. Chamberlain, Montgomery Laboratories, US DHEW, PHS, CDC.

DISCUSSION

The biological vector of EEE virus in Florida is still not established. Presumably the same species of mosquitoes which have been considered as vectors elsewhere, with the possible exception of Connecticut (12), would also be considered in Florida, since all the areas support populations of *Culiseta melanura* and *Mansonia perturbans*.

In the present study, of the 44 species of birds collected, 23 are classified as permanent residents, 10 as both permanent and winter residents, 5 as winter residents (two of which are of questionable identity) and 6 as summer residents (12).

The isolation and identification of EEE virus from six species of passerine birds indicates considerable virus activity in the area.

The laboratory finding of 30 percent "immunes" among the bird population by serum neutralization test is consistent with the findings of others following an epidemic cycle of EEE virus. The four specimens which showed immunity to WEE infection might well be instances of cross-reaction. However, WEE infection was diagnosed in horses in Flagler County, Florida in 1959 (13).

Little has been published in the literature pertaining to the use of the HI test on wild bird sera and a great deal of additional work is indicated. Assuming that the response observed in EEE experimentally infected chicks (wherein HI antibody is consistently demonstrable before serum neutralizing antibody, the latter appearing approximately 10 days following infection (14)) is analogous to the response in wild birds naturally infected with EEE, considerable speculation as to geographical origin of infection may be made. The results of these tests in this study lend strength to the opinion that there is a similarity between the response elicited from chicks following experimental infection with EEE virus and response of wild birds naturally infected with EEE virus.

Of the 17 birds found positive both by HI and serum neutralization tests, none were recognized as immatures. This is interpreted to mean that the birds in this group were infected in a previous year or sufficiently early in 1958 to allow for the development of serum neutralizing antibody by the time the survey was conducted.

The finding of 6 birds negative by HI test but positive by serum neutralization test is interpreted as being indicative of old infections or the result of individual variation among wild birds for the persistence of HI antibody. There is great need for studying the duration of HI antibody in EEE infected wild birds. Once these base-line data have been determined, the value of the HI test in this procedure can be established.

Fourteen birds were positive by HI test but negative by serum neutralization test. Additionally, 3 of the 14 birds were recognized as immature forms, suggesting local hatching. If these 14 specimens, particularly the three immatures, merely had not yet had time to develop serum neutralizing antibody, only two obvious conclusions are possible. Either they became infected just before arriving in the area or they became infected almost immediately after arriving in the area. The sparse information in the literature pertaining to the duration of serum neutralizing antibody in wild birds, experimentally and naturally infected with the virus of EEE, leaves a wide margin for ultimate contradiction. It has been shown in some experimentally infected wild birds that high levels of serum neutralizing antibody are obtained but their duration, as with HI antibody, also is unknown (3). From field and laboratory studies one can conclude that EEE serum neutralizing antibody persists at least one year in certain avian species (3), though to pursue the conclusion beyond this period is difficult to confirm.

Most present workers consider the bird to be the most important key to a full understanding of EEE in the United States. The problem of ascertaining whether the virus is reintroduced each year into the United States by northward migrating birds or whether the virus overwinters in the United States within its endemic range in an arthropod or other animal is a cardinal one. However, once the virus of EEE is found overwintering in the United States in a form which will allow its transmission under favorable conditions, the question of its annual reintroduction by migratory birds will be relegated to almost academic interest. In Florida, bird studies are more complex than in many other areas. Permanent resident species are diluted by northern members of the same species during the winter season. Some of the permanent residents, perhaps accompanied by northern migrants, emigrate to Cuba, Central and South America, Mexico, and probably to other Gulf coast areas of the United States; to immigrate again the following year. This situation serves to complicate field studies and point out the necessity for intimate ornithological assistance.

The study revealed that the virus of EEE was extremely active in localized foci and probably would have precipitated an equine outbreak were the populations of both vectors and susceptibles quantitatively adequate. This leads to the postulation that the virus of EEE in central Florida exists year-round in delimited fresh-water-swamp areas, becoming active during favorable seasons and held in check by the combined influences of susceptible hosts and density of efficient vectors.

Summary

The data obtained during the 1958 Florida study reveal:

a. Absence of detectable virus in the mosquito population during a seasonal period when few equine cases attributable to the virus of EEE were reported in the immediate vicinity. Only 10 equine cases were reported from the study area during 1958 as compared with 67 cases the previous year.

b. The finding of 30 percent "EEE immunes" among the wild bird population by serum neutralization test during the spring and early summer of 1958 con-

firms a widespread exposure to the virus in a previous period, presumably 1957.

c. The detection of HI antibody to the virus of EEE in 14 birds, three of which were immature forms, without detectable serum neutralizing antibody gives rise to the opinion that the infection was recent and of local origin.

d. The relationship of the virological and serological findings to the epidemiology of EEE in the United States is discussed.

References

1. FEEMSTER, R. F., WHEELER, R. E., DANIELS, J. B., ROSE, H. D., KISSLING, R. E., HAYES, R. O., ALEXANDER, E. R., and MURRAY, W. A. 1958. Field and laboratory studies on equine encephalitis. New England Jour. Med. 259:107–113.

2. STAMM, D. D. 1958. Studies on the ecology of equine encephalomyelitis. Amer. Jour. Pub. Health 48:328–335.

3. KISSLING, R. E., CHAMBERLAIN, R. W., SIKES, R. K., and EIDSON, M. E. 1954. Studies on the North American arthropod-borne encephalitides. III. Eastern equine encephalitis in wild birds. Amer. Jour. Hyg. 60:251–265.

4. Surveillance Reports, Arthropod-borne encephalitis in the United States. 1955–1958. U. S. Dept. Health, Ed., and Welfare, PHS, Commun. Dis. Center.

5. CHAMBERLAIN, R. W., RUBIN, H., KISSLING, R. E., and EIDSON, M. E. 1951. Recovery of virus of eastern equine encephalomyelitis from a mosquito, *Culiseta melanura* (Coquillett). Proc. Soc. Exptl. Biol. and Med. 77:396–397.

6. BURBUTIS, P. P., and JOBBINS, D. M. 1957. *Culiseta melanura* (Coq.) and eastern equine encephalomyelitis in New Jersey. Proc. N. J. Mosq. Exterm. Assoc., pp. 68–78.

7. LINCOLN, F. C. 1950. Migration of birds. Dept. of the Interior, Fish and Wildlife Service, Circular 16. 102 pp.

8. Animal Morbidity Reports. 1956–1958. Florida State Board of Health.

9. AUSTIN, L. O. 1959. Curator of Birds, Florida State Museum. Personal Communication.

10. ANONYMOUS. 1957. Arthropod-borne encephalitis. Procedures for investigating outbreaks. Dept. of Health, Ed., and Welfare, CDC, Montgomery Lab. 22 pp.

11. CLARKE, D. H. and CASALS, J. 1958. Techniques for hemagglutination and hemagglutination-inhibition with arthropod-borne viruses. Amer. Jour. Trop. Med. and Hgy. 7:561–573.

12. WALLIS, ROBERT C. 1959. *Culiseta melanura* (Coquillett) and eastern equine encephalitis in Connecticut. Mosq. News 19:157–158.

13. SCATTERDAY, J. E. 1960. Fla. State Bd. of Health. Personal Communication.

14. BYRNE, R. J. and ROBBINS, M. L. 1960. Mortality patterns and antibody response in chicks inoculated with eastern equine encephalomyelitis virus. To be published.

FOR SALE

Used "Tifa" in perfect working condition.

For information write P. O. Box 2743 Sta. B, Toledo, Ohio

CURRENT KNOWLEDGE OF EASTERN ENCEPHALITIS IN MARYLAND[1]

WILLIAM E. BICKLEY AND ROBERT J. BYRNE
Department of Entomology and Department of Veterinary Science, respectively, University of Maryland, College Park

Maryland was one of the eastern states in which the severe epizootic of eastern equine encephalomyelitis occurred in 1933. Some of the first work in isolating the virus from the brains of fatal horse cases and in diagnosing the disease was reported by Brueckner *et al.* (1934). According to U. S. Department of Agriculture annual reports there were 98 equine cases reported in 1938, 70 in 1939, 180 in 1945, 42 in 1955, and 33 in 1956. Smaller numbers of cases occurred in intervening years. In 1959 practicing veterinarians reported 17 cases, and 7 of these were confirmed through laboratory studies conducted under the supervision of the second author. Watson (1959) pointed out that the attack rate in 1959 was actually higher than it was twenty years ago because of the very marked decline in the horse population.

A serological survey for neutralizing antibodies in horses and ponies on the Maryland and Virginia Eastern Shore in 1956 and 1957 showed that 16 of 89 horses tested had significant EEE neutralizing antibodies (Byrne *et al.,* 1959).

The first documented human cases occurred in Maryland in 1956. In that year there were two laboratory-confirmed human cases. There was one confirmed human case in 1959.

In the foregoing paragraphs positive evidence is cited that the virus of the disease now termed eastern encephalitis is present in Maryland, and it may well be concluded that viral activity is not diminishing. Additional information about viral activity has been provided by Moulthrop (1959) who recognized an outbreak of the disease in Chukur partridges near Salisbury. The virus was identified by the second author and a detailed report of this work will be published elsewhere.

Another significant development has been the isolation of the virus from pooled spleens of healthy English sparrows from Laurel, Maryland. Dead birds had previously been noticed in the same area, but the actual cause of death was not ascertained.

Byrne *et al.* (1959) reported on mosquito collections and virus isolation attempts made in 1957 and 1958. In 1957 there were 21 pools of *Aedes sollicitans* (Walker), and in 1958 very limited numbers of tests were run on *A. sollicitans* and six other species. No viruses were isolated. A small number of mosquito pools was tested in 1959.

Newson (1959) reported on a study of the feeding habits of mosquitoes in eight localities on the Eastern Shore where eastern encephalitis had occurred. Precipitin tests were made using specific antisera for horse, cow, pig, human, and avian blood to determine the source of blood meals. The 1,547 mosquitoes tested included 14 species. His results showed that five species, *Aedes sollicitans, A. taeniorhynchus* (Wied.), *A. vexans* (Meigen), *Psorophora ciliata* (Fabr.), and *P. confinnis* (L.-Arr.) might be considered important potential vectors. The range of hosts and potential vector importance of five species could not be determined because too few specimens were collected. A single specimen of *Culiseta melanura* (Coq.) was collected in close association with a confirmed case of encephalitis and was found to have fed on avian blood.

Culiseta melanura is considered to be a rare species throughout the state, and very little is known about actual breeding sites. Light trap records for 1959 showed small numbers at ten Eastern Shore towns.

[1] Miscellaneous Article No. 382, Contribution No. 3129 of the Maryland Agricultural Experiment Station.

The role of this species in the enzootic transmission cycle in Maryland is unknown. It seems hardly possible that it is sufficiently abundant to be of major importance in the bird-to-bird cycle. More information about the over-all abundance and the seasonal and geographical distribution of this species is desirable. The same is true of *A. atlanticus* D. & K., another sylvan species which is widely distributed. Populations of this species never seem to be large. Although it is essentially diurnal in habits it was collected in light traps at 13 localities in 1959. It was most active during the last week of July.

In 1959 unusual rains and tides in the Chesapeake Bay area contributed to extremely heavy populations of salt-marsh mosquitoes and fresh water species such as *Psorophora confinnis* which are associated with temporary rain pools. This was true in 1933 and in most other years when eastern encephalitis outbreaks have occurred.

In conclusion, mention should be made of the work of John E. Scanlon. Currently in progress are studies (undertaken with support from the U. S. Army Medical Research and Development Command) which deal with the vector potentialities of 2 species of *Culicoides* (Diptera: Ceratopogonidae). Tentative conclusions are that these biting midges are not involved in the transmission of EE virus in Maryland.

Literature Cited

BRUECKNER, A. L., POELMA, L. J., EVERSON, C. L., and REED, R. C. 1934. Equine encephalomyelitis. Univ. of Md. Agric. Expt. Sta. Bull. 369:137–146.

BYRNE, R. J., YANCEY, FRANCES S., BICKLEY, W. E., and FINNEY, GARLAND. 1959. Epidemiological studies on equine encephalomyelitis in Maryland and Virginia. Journ. Amer. Vet. Med. Assoc. 135(4):211–215.

MOULTHROP, I. M. 1959. Communication at Symposium on Eastern Equine Encephalomyelitis, University of Maryland, November 18, 1959.

NEWSON, H. D. 1959. The feeding habits of Maryland mosquitoes in relation to eastern equine encephalomyelitis. Ph.D. thesis, University of Maryland.

WATSON, ROBERT. 1959. Communication at Symposium on Eastern Equine Encephalomyelitis, University of Maryland, November 18, 1959.

MOSQUITO SURVEILLANCE AND ABATEMENT AT FORT DIX, NEW JERSEY DURING THE EASTERN EQUINE ENCEPHALITIS OUTBREAK OF 1959

MILTON B. FLEMINGS,[1] IRVING H. WALLER,[2] AND HENRY ESTES[3]

During the second week of August 1959, approximately 50 pheasants of a flock reared by the Rod & Gun Club of Fort Dix displayed disease symptoms. New Jersey State laboratory tests were made and positive isolations of eastern equine encephalitis virus (EEE) from 8 of 50 sick birds were confirmed (5). Since these findings represented a potential threat to the health of the command, special mosquito surveillance of the entire Fort Dix area was immediately initiated, and based upon the results, mosquito control activities were intensified and expanded.

In late August, a sharp focal outbreak of EEE in humans came to notice in several counties along the coastal area of Central and Southern New Jersey (7). EEE virus had been demonstrated in mos-

[1] Major, MSC, Entomologist, First U. S. Army Medical Laboratory, 90 Church Street, New York 7, New York.

[2] Entomologist, Hq. First U. S. Army Engineers, Governors Island, New York.

[3] Entomology Assistant, First U. S. Army Medical Laboratory, 90 Church Street, New York 7, New York.

quitoes, wild birds, pheasants, and horses for many years in the State, but this was the first instance of confirmed EEE in humans. This unique event, comparable only to the Massachusetts EEE outbreak of 1938 (6), created unusual interest.

It was of particular interest to Army officials in that several major military installations with large troop populations (one of which was Ft. Dix) and several Nike AAA sites were located in the general area of the affected counties. Fort Dix is located 20 miles southeast of Trenton, N. J. The acreage (approx. 33,000 acres) is largely composed of second growth oak and pine woodland, with scattered cedar-type swamps, sassafras, a few abandoned cranberry bogs, and other formerly cultivated fields. The reservation is bordered mostly by woodlands of the same type. Generally, there is a growing season of approximately 205 days each year. The topography ranges from 50 to 200 feet elevation.

Procedure

Surveillance. Routine mosquito surveillance began as usual at Fort Dix on 1 April. Due to indication of EEE activity in the area, special mosquito surveillance was undertaken on 17 August 1959 in accordance with methods described by Chamberlain 1959 (4). It consisted of adult population determination with 5 New Jersey type light traps and 3 artifical resting containers; larval population determination by routine larval dips; and intense searching for the breeding source of *Culiseta melanura* (Coq.) a known vector of EEE. Mosquito light trap records at Fort Dix for 1955–58 were used to compare the 1959 results. Average weekly meteorological data were obtained from the nearest weather station (1).

From 1 April to 16 August 1959, one light trap was operated at each of the following areas of Fort Dix, the same areas where they were operated throughout the mosquito season for the past five years:

#1—Dependent Housing Area
#2—Troop Housing Area
#3—Bivouac Training Area
#4—Troop Housing Area
#5—McGuire Air Force Base Troop Housing Area

On 17 August, light traps #2 and #4 were re-located at the pheasant farm and the nearby Officers' Open Mess Annex, which were within the woodland section of the post, and from which the nearest cedar-type swamp was about a 3/4 mile distance. Traps 1, 3 and 5 were retained in the original areas which were approximately 3–5 miles distant from the nearest cedar-type swamps.

Artificial mosquito resting containers, consisting of regular size kegs with black interiors, 4 square inch openings, and removable tops, were placed in the general areas of traps 2 and 4 to collect live mosquitoes for virus studies, and to further determine the *Culiseta melanura* population index.

Typical *Culiseta melanura* breeding sources, as described by Burbutis, Lake and Jobbins 1956 and 1957 (2, 3) were used as guides in the intensive search for local breeding of this species. Routine larval collections throughout the post and bivouac training areas continued on a weekly basis.

Control. Mosquito control operations were the responsibility of Post Engineers whereas mosquito surveillance was a medical responsibility. The surveillance team performed weekly inspections of all phases of the mosquito program and reported its findings to the Engineers. Control efforts were usually accomplished within 3 days, but never exceeded one week.

Since Fort Dix was subjected to adult mosquito infiltration from surrounding areas, an adulticiding program consisting of routine thermal aerosol fogging with DDT was continued throughout the summer in the cantonment and bivouac training areas. The installation was divided into zones and each zone treated in succession several times each week.

Routine weekly larval control was accomplished by treating the common mosquito breeding places with standard 5

percent oil based DDT and a combination 4 percent BHC—12-1/2 percent DDT formulation. The latter was dispersed in gelatin capsules commonly known as "tossits."

Due to a high *C. melanura* population index, human activities in selected woodland areas of the post were limited during the period 1 September to approximately 1 November. This ruling affected the dependents' bathing beach, the Officers' Open Mess Annex, and other activities.

On 15 September, additional adult mosquito control measures were recommended and immediately employed. The woodland areas showing high *Culiseta melanura* counts were subjected twice weekly to a mist-blown application of standard issue 5 percent DDT. Bivouac training areas and housing areas having lower *Culiseta melanura* counts were treated once per week.

Because of difficulties experienced in gaining entrance into the extensive ordnance impact area (the nearest source of *Culiseta melanura*), and as a last resort, additional adult mosquito control by means of aircraft spraying was recommended. On 29 September and 2 October, approximately 11,000 acres comprising approximately one-third of the entire post area were sprayed by C-47 aircraft from the U.S. Air Force Special Aerial Spray Flight. Malathion insecticide was dispersed at the rate of .2 to .3 pounds per acre.

RESULTS AND DISCUSSION

Adult *Culiseta melanura* was first encountered in light traps during the week of 25–31 May (only 4 specimens), again on 10 June (only 1 specimen), and not again until August at which time the number had increased enormously. Figure 1 is a graph showing the quantitative mosquito light trap collection at Fort Dix

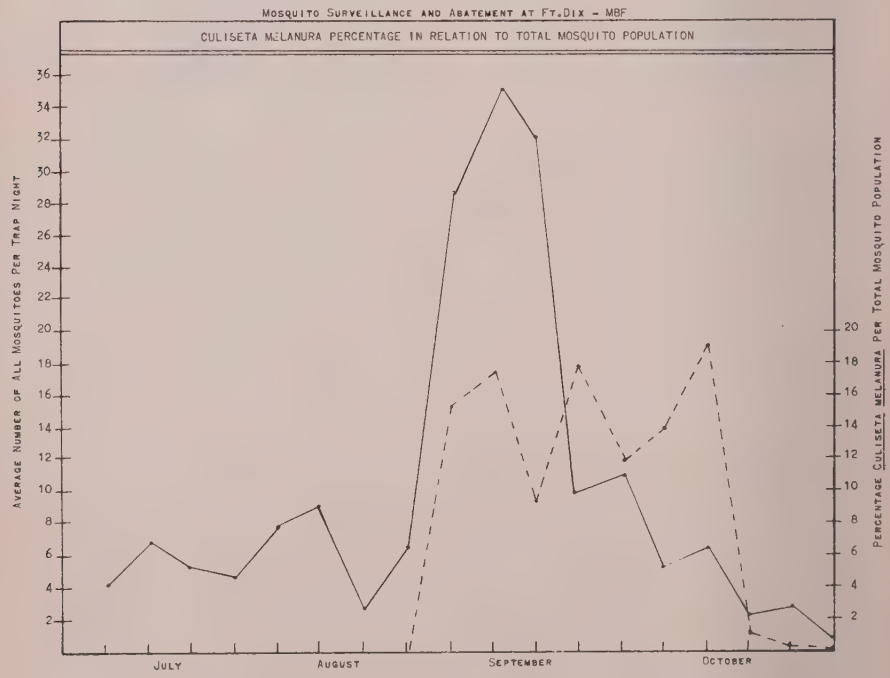
MOSQUITO SURVEILLANCE AND ABATEMENT AT FT. DIX - MBF
CULISETA MELANURA PERCENTAGE IN RELATION TO TOTAL MOSQUITO POPULATION
AVERAGE NUMBER OF ALL MOSQUITOES PER TRAP NIGHT
PERCENTAGE CULISETA MELANURA PER TOTAL MOSQUITO POPULATION
JULY
AUGUST
SEPTEMBER
OCTOBER

FIG. 1.

from 29 June to 31 October 1959. It compares the percentage of *Culiseta melanura* to the total mosquito collection.

Culiseta melanura ranged from 22 percent of the total mosquito collection per trap/week (31 Aug.–6 Sept.) at the Officers' Open Mess Annex (trap 4) to 4 percent per trap/week throughout the Post cantonment and bivouac training areas (traps 1, 3 and 5). Trap #2, which was located at the pheasant farm, produced relatively few *Culiseta melanura.* Traps #2 and #4 were approximately three-quarters of a mile from the nearest *C. melanura* breeding source. Traps #1, 3 and 5 were approximately 3–5 miles from the nearest *C. melanura* breeding source.

The general mosquito population index remained constantly high while routine larviciding and fogging were the only chemical measures employed for control; however, personnel within the cantonment and bivouac-training areas reported temporary relief from adult mosquitoes due to the fogging program.

Immediately after commencing the DDT misting operation (15 September), the general mosquito population index (including *C. melanura*) dropped from 34 mosquitoes per trap night to 9, and remained about that level until the late aerial spray which further reduced the index to 4 mosquitoes per trap night. Three days after the aerial spray (29 Sept. and 2 Oct.), the mosquito population index began to rise rapidly until cold weather (12–18 Oct.) suddenly reduced the index to near zero.

Adulticiding (misting and aerial spraying) successfully reduced the general mosquito population index (including *C. melanura*); however, all species population index did not drop proportionately. Significantly at this time, there was a percentage increase of *Culiseta melanura* compared to the total mosquito collection.

Table 1 compares, by months, the average number of selected species collected per trap/week at Fort Dix from 1955 through 1959. The *Culiseta melanura* population is shown to be unusually high in 1959 as compared to previous years. The general mosquito population index was also higher during 1959. During 1955 and 1959, the general mosquito population peak occurred in September, while in 1956 through 1958 it occurred in July or August. There were no *Culiseta melanura* trapped during the latter years.

After an intense search for the breeding source, *Culiseta melanura* larvae were finally discovered in a cedar-type swamp located within the Post Ordnance Impact Area which was approximately three-quarters of a mile from the Officers' Open Mess Annex where the highest adult *C. melanura* counts were recorded.

C. melanura larvae were located in ground level tree holes which were too small for the regular larval dipper (5 in. dia.), and under the extensive root systems of the cedars. Often dead leaves and other debris covered the root systems so that one may not have ascertained that water was beneath. The swamp was dense with second growth cedar and other larger trees that provided constant shade throughout the day. The water was cool, tea colored, with a pH range of 4.4 to 5.5. All larval instars were present and collections averaged approximately 3–8 larvae per dip. *Culex territans* (Walker) were commonly found breeding in association with *C. melanura.* Occasionally, *Culex pipiens* (Coq.) *Culex salinarius* (Coq.) and *Anopheles punctipennis* (Say) were present.

Routine weekly larval collections from common breeding sources within the cantonment and bivouac-training areas were often negative throughout the season, perhaps due to routine larval control efforts. The few positive collections always confirmed the qualitative adult mosquito light trap counts, but not the quantitative counts, perhaps due to adult infiltration from "off post." Larval counts were never sufficient to account for the local adult mosquito population as indicated by the light trap counts.

Few mosquitoes were collected from the artificial resting containers. The number was insufficient for virus studies.

TABLE 1.—Fort Dix mosquito light trap collection averages per trap/week for selected and other species 1955–1959, July through October

Species	1955				1956				1957				1958				1959			
	July	Aug.	Sept.	Oct.	July	Aug.	Sept.	Oct.	July	Aug.	Sept.	Oct.	July	Aug.	Sept.	Oct.	July	Aug.	Sept.	Oct.
Aedes sollicitans	10	36	4	1	163	11	3	1	3	10	11	0	27	19	1	1	8	8	19	0
Aedes vexans	12	93	54	5	2	18	20	7	42	14	17	2	55	147	56	7	5	35	168	17
Culex spp. (total)	64	54	132	75	289	305	174	3	42	243	173	33	265	239	249	36	150	285	363	57
Culiseta melanura	2	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	39	78	11
Other species	2	8	12	1	1	8	1	1	5	1	2	0	4	8	3	2	2	16	36	2

Temperature and relative humidity ran substantially the same pattern each year, 1955–59. Temperature more or less leveled between 70 and 80 degrees Fahrenheit during July and August, dropping gradually each month thereafter. Relative humidity averaged approximately 73 percent.

Precipitation records of the Ft. Dix Area for 1955 and 1959, the years of EEE outbreaks in Massachusetts and New Jersey respectively, indicated heavy rainfalls followed by relatively long dry periods. The year preceding the New Jersey outbreak, heavy rainfalls occurred in October, which may have substantially contributed to an abnormally high overwintering population of *C. melanura*. This in turn would have provided a large initial population for the mosquito season of 1959.

Summary

A special mosquito surveillance and abatement program was initiated at Ft. Dix, N. J., immediately after confirmation of eastern equine encephalitis in a local pheasant flock. Thirty-four recorded human EEE cases later occurred in several counties of New Jersey. Ft. Dix was located partly in one of the affected counties.

In addition to routine mosquito surveillance operations, a special survey was made to determine the breeding source of *Culiseta melanura* (Coq.). Breeding was found only in cedar-type swamps with typical ecological environs.

Routine mosquito abatement measures were intensified and augmented by mist blown operations in sensitive areas. Outlying areas which were inaccessible to ground equipment were treated by late aerial spraying.

Weekly misting operations successfully reduced the general adult mosquito population throughout the post. The aerial spray was only initially effective for 2–4 days. Routine fogging and larval control did not satisfactorily reduce the adult population index; however, fogging gave temporary relief to local personnel.

Mosquito light trap records of Ft. Dix for the past five years suggest that a correlation may have existed between the unusually high 1959 *C. melanura* population and the EEE outbreak which occurred in the State of New Jersey. Numerous *C. melanura* were encountered in 1959 compared to a few in 1955 and none in 1956 through 1958.

References Cited

1. Anonymous. 1955–1959. Meteorological Data. Weather Central, Long Branch, New Jersey.

2. Burbutis, P. P. and Lake, R. W. 1956. The biology of *Culiseta melanura* (Coq.) in New Jersey. Proc. New Jersey Mosq. Ext. Assoc. 43: 155–161.

3. Burbutis, P. P. and Jobbins, D. M. 1957. *Culiseta melanura* (Coq.) and eastern equine encephalitis in New Jersey. Proc. New Jersey Mosq. Ext. Assoc. 44:68–78.

4. Chamberlain, R. W. 1959. Procedures for investigating outbreaks of arthropod-borne encephalitis. U. S. Dept. H. E. W., CDC, Atlanta, Ga.

5. Failing, F. W. 1959. Post veterinarian, Ft. Dix, N. J. Personal communication.

6. Feemster, R. F. 1957. Equine encephalitis in Massachusetts. New England J. Med. 257: 701–704, 728, 732–733.

7. Hayes, R. O. 1959. CDC activities, USPHS, Taunton, Mass. Personal communication.

SOME FACTORS INFLUENCING LARVAL POPULATIONS OF *CULEX TARSALIS* AND WESTERN EQUINE ENCEPHALITIS IN UTAH[1]

JAY E. GRAHAM,[2] IVER E. BRADLEY,[3] AND GLEN C. COLLETT[4]

In 1956 the South Salt Lake County Mosquito Abatement District began a detailed larval survey to obtain more information about mosquito larval populations and the factors that influence them in Salt Lake County. This survey has been continued in each subsequent year, and in 1959 the Salt Lake City Mosquito Abatement District conducted a similar survey. Inspectors employed by the districts were required to collect a sample of larvae from each spot where they were found and record the date, location, number of larvae per dip, the instar of the larvae, the size of the body of water producing them, and the source or nature of the water. The larvae were later identified in the laboratory. The data obtained in this manner gave valuable information regarding mosquito larval populations and suggested several problems for future investigations which will be conducted by the mosquito abatement districts and the Department of Entomology of the University of Utah. This paper considers some of the data on *Culex tarsalis* and their significance.

Approximately 9,000 samples of mosquito larvae were taken in the four years of the survey in South Salt Lake County. The average number of larvae per dip for all of the pools sampled each year was less when 1 species of mosquito was found than when 2 or more species were found, but the difference was less than would be expected if each species was as numerous in the pools with multiple species as when found alone.

Figure 1 is a graph showing the percentage distribution of pools according to numbers of larvae per dip for single and multiple species for 1959. The patterns for other years are similar.

At least one of the species is reduced in numbers when two or more species

TABLE 1.—Comparison of the number of larvae per dip in pools with single and multiple species for 4 years in Salt Lake County

Year	No. of pools sampled	Average number of larvae per dip		
		Single species	Multiple species	All pools
1956	1206	7.4	7.9	7.5
1957	1825	5.9	6.9	6.2
1958	3171	3.7	4.5	3.9
1959	2666	5.0	5.7	5.3

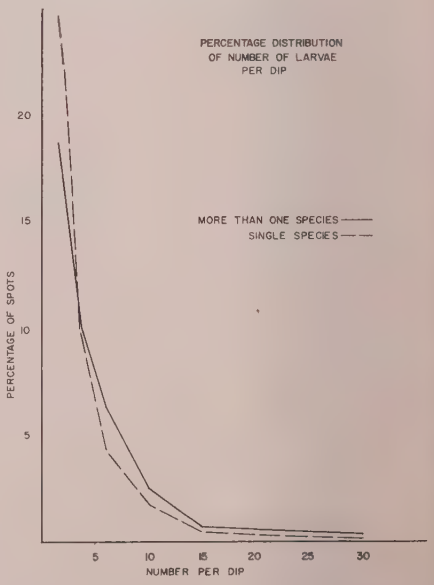

FIG. 1.—Percentage distribution of pools according to numbers of larvae per dip for single and multiple species.

[1] This study was supported in part by National Institutes of Health grant E-3067.

[2] South Salt Lake County Mosquito Abatement District.

[3] University of Utah.

[4] Salt Lake City Mosquito Abatement District.

share the same larval habitat. Although the total number of larvae is greater, field observations indicate that the larvae of all species are less numerous when they share a habitat with other species than when they are alone. A possible explanation for this is that competition, in some form, restricts the density of mosquito larval populations but since different species occupy slightly different niches in the same habitat, competition is reduced to some extent.

Since two or more species of mosquito larvae in any one habitat appear to reduce the numbers of each species compared to the habitats where they are found alone, the number of times the larvae of any particular species can occupy a habitat by itself has a direct relation to the total number of mosquitoes produced.

TABLE 2.—Comparison of the percentage of pools of *C. tarsalis* larvae only with cases of WEE for 4 years in Salt Lake County

Year	Pools	Percentage of pools with *C. tarsalis* only	Cases of WEE in horses
1956	510	46.7	11
1957	982	58.7	77
1958	2230	66.0	224
1959	1333	41.1	21

Table 2 is a table showing the number of times *C. tarsalis* was found, the percentage of times it was found alone and the number of cases of western equine encephalitis reported in horses in Utah, for the 4 years of the larval survey. The apparent relationship between the percentage of times that *C. tarsalis* is found alone and the number of cases of WEE reported in horses in Utah is possibly a reflection of the total numbers of *C. tarsalis* produced.

The seasonal distribution and abundance of *C. tarsalis* partially explain some factors which influence populations. Bates (1954: 41) says of seasonal distribution and abundance "Indeed, the adaptations of a particular species to factors in the physical environment (climate) may be as clearly shown by the seasonal distribution of the species as by the habitat or geographical distribution and it may be as difficult to isolate the particular limiting factors that control abundance in time as it is to isolate those that control distribution in space."

Figure 2 is a graph showing the seasonal distribution of the number of pools with larvae of *C. tarsalis* for the four years of the survey. The graph is based on the number of pools with larvae and is not a direct measurement of larval population, but does indicate changes in larval population during the year and from year to year. Also, increases in the number of spots with larvae of *C. tarsalis,* such as occurred in 1958, indicate greater dispersion of the species in the area which may be an important factor in the transmission of WEE.

The local factors responsible for changes in *C. tarsalis* populations during the year and from year to year are not completely known. Rees *et al.* (1959) attributed the 1958 increase in populations of *C. tarsalis* in Utah and the subsequent epidemic of WEE in horses and humans to an above normal snowfall in the winter and to a dry hot summer requiring increased irrigation. The amount of snowfall during the winter and the amount of precipitation during the summer months can be compared with larval population of *C. tarsalis* from 1956 through 1959. Adequate data on *C. tarsalis* populations prior to 1956 are not available for comparison. However the Bureau of Animal Industry U.S.D.A. has kept records of the numbers of cases of WEE reported in horses in Utah since 1943. Populations of *C. tarsalis* probably fluctuated with the number of cases of WEE in horses during this period.

Certain weather factors seemed to be related to changes in *C. tarsalis* populations in the 4 years of the survey. These same weather factors showed the same relationship to cases of WEE reported in horses in Utah since 1943 (Table 3). The weather factors which are apparently responsible for increased *C. tarsalis* popula-

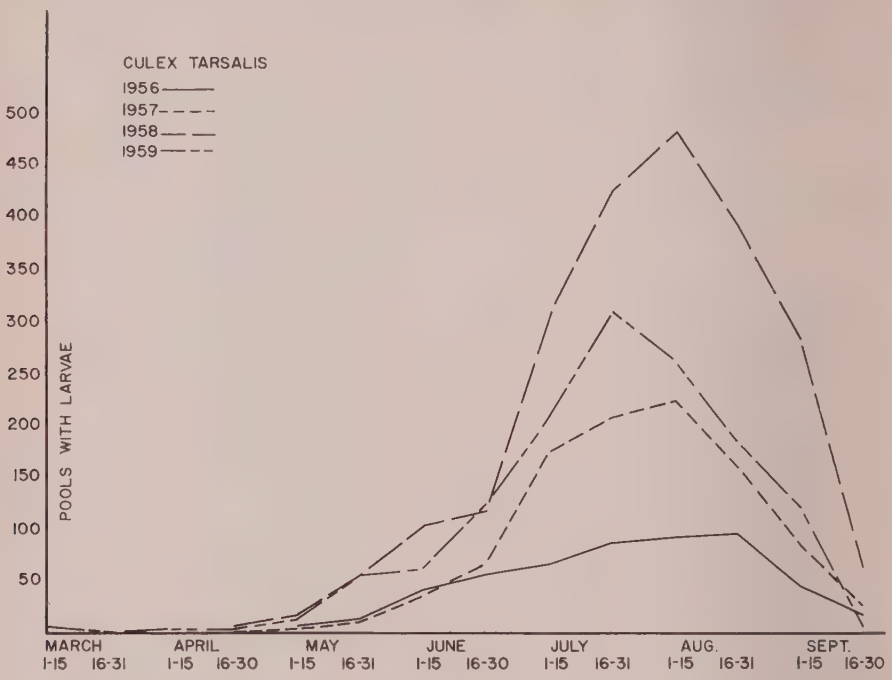

FIG. 2.—Seasonal distribution of the number of pools with *Culex tarsalis* for 4 years in Salt Lake County.

TABLE 3.—Comparison of some weather factors with cases of WEE in horses in Utah from 1943 through 1959 arranged in order of decreasing numbers of cases of WEE.

No. of horse cases of WEE in Utah	Year	Snow pack percent of normal	Precipitation deviation from normal to nearest 0.5 inch	
			June	July
249	1952	225	+.5	—.0
224	1958	125	—1.0	—.5
167	1943	65	+1.5	—.5
77	1955	110	+.5	—.5
70	1947	95	+2.0	—.5
62	1944	175	+2.0	—.5
59	1945	75	+1.5	—.0
39	1946	90	—.5	—.0
36	1948	105	+1.5	—.5
24	1955	136	—.0	—.5
21	1959	80	+.5	—.5
18	1949	170	—1.0	—.5
11	1956	110	—.5	—.5
9	1950	105	—1.0	+.5
8	1953	70	+.5	+.5
5	1954	80	—.0	+.0
0	1951	70	—1.0	+1.5

tions and the incidence of WEE in horses in Utah are above normal precipitation early in the year, usually in June but sometimes in May or April or as snowfall during the preceding winter months, and an unusually dry period beginning in July and extending through at least half of August. Above normal snowfall will affect the amount of moisture available later in the year because snow in the higher mountains does not melt until May or June. Madsen (1934) reports a large number of horse cases of WEE in Utah in 1933. This year also fits the above precipitation pattern of above normal precipitation early in the year and below normal precipitation during the summer. Since normal summer precipitation in Utah is only about one inch per month, below normal precipitation results in almost no rain.

Years in which low numbers of cases of WEE reported in horses generally have below normal precipitation in June and preceding months and above normal rainfall in July. Apparently rainfall during July and early August is detrimental to the transmission of WEE in horses in Utah due possibly to the effects of rainfall on *C. tarsalis* populations. In this regard it is interesting to note that the number of sites with *C. tarsalis* larvae in 1959 reached a peak in the last half of July rather than the first half of August as in the other three years of the larval survey. The decline of *C. tarsalis* populations that occurred in the first half of August in 1959 may have been due to rainstorms that occurred during that period.

Most mosquito production in Utah is the result of the activities of man, particularly irrigation practices. The reaction of man to the above weather conditions is therefore a significant factor in changes in mosquito populations.

SUMMARY AND CONCLUSIONS. The South Salt Lake County Mosquito Abatement conducted detailed larval surveys from 1956 through 1959. The Salt Lake City Mosquito Abatement District conducted a similar survey in 1959. Approximately 9,000 pools were sampled in the survey in South Salt Lake County.

The average number of larvae per dip for all pools sampled each year was slightly greater when more than one species was found in a pool than when one species was found alone. However, the number of larvae of each of the species in pools with multiple species were less numerous than when the species was found alone. Apparently competition in some form restricts the density of larvae in each pool, but since different species occupy slightly different niches in the same habitat, competition between individual larvae is reduced. The number of times a species of mosquito can occupy a larval habitat alone has a direct relationship to the total number of mosquitoes produced. For the four years of the survey there was a positive correlation between the percentage of times *C. tarsalis* larvae were found alone and the number of cases of WEE reported in horses.

Certain weather factors seemed to be related to changes in *C. tarsalis* populations in the four years of the survey. These same weather factors showed the same relationship to cases of WEE reported in horses since 1943. The weather factors which apparently result in increased *C. tarsalis* population and increased incidence of WEE in horses in Utah are (1), above normal precipitation early in the year, usually in June but sometimes in May or in the winter months; and (2), and an unusually dry period beginning in July and extending through at least half of August. Irrigation practices are an important factor in changes in mosquito populations.

References

BATES, MARSTON. 1954. The natural history of mosquitoes. Macmillan Co., 379 pp.

MADSEN, D. E. 1934. Equine encephalomyelitis. Utah Academy Sciences, Arts and Letters XI:95–99.

REES, D. M., OGDEN, L. J., COLLETT, G. C. and GRAHAM, J. E. 1959. The 1958 encephalitis outbreak in northern Utah 3. Mosquito populations in relation to the outbreak. Mosquito News 19: 227–231.

SAFETY PROCEDURES IN MOSQUITO CONTROL OPERATIONS

A CONTRIBUTION TO THE SYMPOSIUM ON MOSQUITO CONTROL OPERATIONS

FRANKLIN C. WRAY
Technical Director, Desplaines Valley MAD, Lyons, Ill.

Routine practice in nearly all district shops and garages requires observance of standard safety measures such as fire extinguishers, fire walls and doors, no smoking, goggles, first aid kits, etc.

In mixing insecticides, degree of precaution varies with degree of toxicity of material being used. In our district only DDT is in use. The degree of precautionary methods used is determined by toxicity of material. Goggles, respirators and rubber gloves are a must, but the proper types must be used to give maximum protection against material being handled. Likewise, these pieces of equipment should meet approval of the Board of Underwriters and insurance companies.

Recommendations of the U. S. Bureau of Entomology and Plant Quarantine have been published in *Entoma;* similar recommendations are made in other publications such as the California Mosquito Control bulletin, *Pest Control* Magazine, CDC training guide on insecticides, and National Agricultural Chemicals Association.

Other mixing room precautions should include keeping insecticides under lock and key, properly labeled, use of fans or blowers, no smoking, frequent change of clothing, washing thoroughly after contact, posting of antidotes for insecticide poisoning, doctors' names and phone numbers, and phone number of nearest Poison Control Center.

Recommendations have been made that all personnel be given a minimum of two pre-exposure cholinesterase tests prior to each season's spraying program where phosphates are in use.

Possibly the biggest question in regard to safety requirements is, "How well are they observed and what measures are employed for enforcement?" Do districts know or realize potential and actual dangers? Do they take all recommended precautions or just trust to luck?

It is general practice to require a doctor's certificate before an employee can return to work after an illness of three or more days. This affords protection to both the employer and employee if any question as to physical fitness arises. In case of exposure to chemicals, presumably such exposure is or should be taken into consideration by the physician.

In our district accurate records are kept of each batch of insecticide mixed, kinds and amounts of oils, chemicals, emulsifiers used, and rate to be applied. Such certificates can be signed only by the general foreman or technical director and mixing can be done only in their presence.

Our most serious safety problem in field operations is in night adult control where thermal fog generators are used.

Only nine of the 250,000 plus tax payers are on record as objecting to fogging on theory that it affects their health. We don't question this, but turn off machine while passing their homes, or notify them so that they can leave home while fogging is under way.

Another nine or ten object on grounds that it harms the birds and bees, fish, etc. or contaminates their vegetable gardens; and two just don't like the idea. Some rush to open their windows; others to shut theirs.

Toxic effects to our personnel are practically non-existent as they are rarely in the fog themselves if full advantage is taken of the wind direction. The same thing is true probably of children running in fog as their actual contact with fog is usually a matter of only a few seconds.

Safety precautionary measures our district has adopted include headlights, taillights, and rotating red light on top of cab

lit at all times. Red reflectors are used on some trucks and all have rear bumpers painted with black and white stripes. Some districts have used large warning signs with luminous paint.

We would like to drive the wrong way on one-way streets or barricade streets being fogged but have been advised by local police that this is illegal without ordinance by local governing board.

Drivers of fogging units are expected to keep on right side or middle of street, never on left hand side or left shoulder, even if permitted. It would be interesting to know the viewpoint of insurance companies in this or in driving wrong way on one-way street.

The police are notified each night in each village to be fogged and articles in local papers warn the public to avoid getting in fog with resultant danger of traffic accidents. In exceptional cases we have asked for and received police escorts.

No streets with heavy traffic are fogged before midnight and then only if fog is blown off of street immediately. In general, we have found it preferable to do such streets in day time with a mist-blower.

The ever present danger of fire requires that the driver must have fire extinguisher on seat beside him—every second counts—and tail gates are tilted sufficiently to prevent pools of oil gathering on tail gate. We know of a fire that resulted from this pooling of oil.

Any machine that develops gasoline leaks is sent back to garage and remains inoperative until leak is fixed regardless of how much it is needed in the field.

Tachographs are installed on all trucks. These indicate if truck is moving, speed and distance travelled, and serve both as a check on the driver and protection to the driver from mistaken critics. Likewise, a mobile phone is installed in the foreman's truck, enabling any driver to contact him immediately in case of an accident or any other problem that may arise.

Problems that still defy satisfactory solution include children running in fog, inviting danger of being struck by careless motorists. The most irritating thing is to see the children doing this and parents standing on the porch making no effort to cooperate. Cars collide under the same conditions. A police car was guilty of this in one village and a child injured in another case. Other districts have had similar mishaps, some of them very serious.

AIRPLANE APPLICATION OF GRANULAR PARIS GREEN MOSQUITO LARVICIDE

ANDREW J. ROGERS AND CARLISLE B. RATHBURN, JR.[1]
Florida State Board of Health, Entomological Research Center

This is the third in a series of papers reporting on the development and application of a new granular formulation of paris green for control of both anopheline and culicine mosquito larvae. The first paper (Rogers and Rathburn, 1958) outlines early procedures for formulating paris green on vermiculite and gives test results against salt-marsh *Aedes, Psorophora,* and *Anopheles* larvae. The second paper (Rogers and Rathburn, 1960) describes improved methods of formulating this larvicide.

The light weight of the original formulation (12 pounds per cubic foot) makes it very desirable for application at ground

[1] The authors hereby gratefully acknowledge the indispensable cooperation of Mr. E. J. Beidler, Director, Indian River Mosquito Control District, and his staff in the conduct of this study.

level. However, because of the adverse effects of variable-velocity winds on dosage patterns when applied from the air, this light bulk density proved to be a disadvantage in airplane application. Therefore research was continued in 1959 to find satisfactory solutions to the problems associated with airplane application of this larvicide. This paper describes the methods and results of this research.

FORMULATION

The first objective was to make the formulation heavier. By reducing the vermiculite content on a hundredweight basis from 53 to 35 pounds and increasing the other materials proportionately, a balanced formula was obtained which weighs about 19 pounds per cubic foot or approximately 50 percent more than the original formula. The formula recommended for airplane application is as follows, per hundredweight.

Vermiculite	35
Emulsifiable oil	40
Powder	25
Total	100

MATERIALS

Vermiculite—The larvicide was further improved for airplane application by use of a more uniform, dust-free grade of vermiculite. Through co-operative efforts between the Florida State Board of Health and the Zonolite Company, there was produced at the Jacksonville, Florida plant of the Company in 1959 a special grade of vermiculite for use in the recommended airplane formula of granular paris green. This product, designated by the Zonolite Company as Florida Chemical Carrier No. 3, is a 10/30 mesh grade with approximately 85 percent by weight in the 10/20 mesh size; minimum weight is 23 pounds per four-cubic-foot bag. Accepted sieve analyses on this grade of vermiculite are shown in Table 1.

Oils and Emulsifiers—Recommended oils and emulsifiers were discussed in detail by Rogers and Rathburn (1960). These same materials are recommended for use in the airplane formula. The oils are all horticultural-type spray oils. They are: Standard Oil Co., No. 341 and No. 345; and Gulf Oil Co., No. 361 and No. 562. The emulsifier found to be most effective to date is Triton N-101. (Rohm & Haas Co.)

TABLE 1.—Percent by weight of Florida Chemical Carrier No. 3 grade vermiculite retained on U. S. Standard Sieves (percentages not accumulative)

Sieve No.	Minimum	Maximum
10	0.0	1.5
16	20.0	55.0
20	40.0	90.0
30	0.0	10.0
Pan	0.0	5.0

Paris Green Powder—In order to control the concentration of paris green in the airplane formula, the commercial-grade paris green is first diluted with an inert powder of similar particle size and weight. As shown in Table 2, 25 pounds of the proper blend then are used for each 100 pounds of formulation. Marble dust, a by-product of the marble industry, is one inert powder that is satisfactory for diluting the paris green.

Several of the commercially-available paris green powders have been tested against salt-marsh *Aedes* larvae in the development of this product, and all have been shown to be effective.

FORMULATING PROCEDURE

The method of mixing this formula is the same as previously outlined (Rogers and Rathburn, 1960). The vermiculite is placed in a rotating-drum mixer and the oil containing by volume 10 percent of Triton N-101 is sprayed over the vermiculite as it mixes. Since the Triton is not completely soluble in the oil, the mixture should be agitated as it is sprayed. The required blend of paris green powder is then added in smaller portions but at a total rate of 25 pounds per 100 pounds of formulation.

When the paris green is well mixed with the vermiculite, the larvicide may be bagged directly from the mixer for use or storage. Storage qualities appear to be

TABLE 2.—Diluting 90% paris green powder with inert diluent for use in making granular paris green mosquito larvicide

Paris green by weight desired in finished formulation (%)	Per 100 lbs. of blend use		Pounds of blend to use per 100 lbs. of formulation
	90% paris green-lbs.	Marble dust-lbs.	
2.5	12	88	25
5.0	23	77	25
7.5	34	66	25
10.0	45	55	25

excellent even for periods of several months duration; however, no specific studies have been made on storing of the larvicide.

EQUIPMENT

The new formula first was applied in swath and pattern studies on a grass airstrip. Crop-dusting Stearman airplanes equipped with commercially-available distributors were used in these tests and in subsequent tests against mosquito larvae. In the swath studies, the airplanes were flown 80 m.p.h. on a measured course with the airplane crossing at a 90° angle over a line of wooden trays placed on 5 or 10-foot centers on the grass strip. The trays were 3 inches deep and 2 feet square. The granular paris green caught in each tray was placed in individually numbered vials and weighed on an analytical balance. Dosage curves were then plotted from these data.

For economy and effective insect control, two factors stand out in airplane application of insecticides: uniform distribution of the insecticide and the width of the effective swath. The swath tests conducted in this study pointed up the vast differences in dispersing equipment as they relate to these two factors.

All of the early airplane tests with granular paris green, extending as far back as 1957, were made with two commercial distributors widely used for airplane crop dusting. The best average swath width that could be obtained with either of these distributors with granular paris green was about 30 feet. Also, the distribution within the swath was very erratic, often with gross overdosing or underdosing in "strips." This same irregular pattern was revealed in larvicide tests conducted in 1958 and early 1959, there being narrow "strips" in many test plots with 100 percent larval kill adjacent to "strips" with little or no kill. Results of this type obviously reflect poor application—not insecticide failure.

In June, 1959 the Indian River Flying Service of Vero Beach, Florida, owners and operators of the airplanes used in these tests, purchased a new Swathmaster [3] distributor and mounted it on a 450 h.p. Stearman airplane. This unit proved to be so much more effective than those previously used that the latter were not used again.

The Swathmaster unit distributed the granular paris green in an effective swath of 60 feet, with a total spread of about 100 feet. Fig. 1a. shows a typical dosage curve (actual) from a single swath and Fig. 1b. represents the dosage pattern obtained with multiple swaths flown on 60-foot flight centers with this unit. While these patterns might appear to deviate considerably from the theoretical horizontal dosage line representing 15 pounds per acre, the patterns are much superior to those obtained with the other distributors tested at half this swath width.

LARVICIDE TESTS

Tests were conducted in the summer and fall of 1959 against larvae of *Aedes taeniorhynchus* (Wied.) and *Aedes sollicitans*

[3] Distributed by Transland Aircraft, Torrance, California.

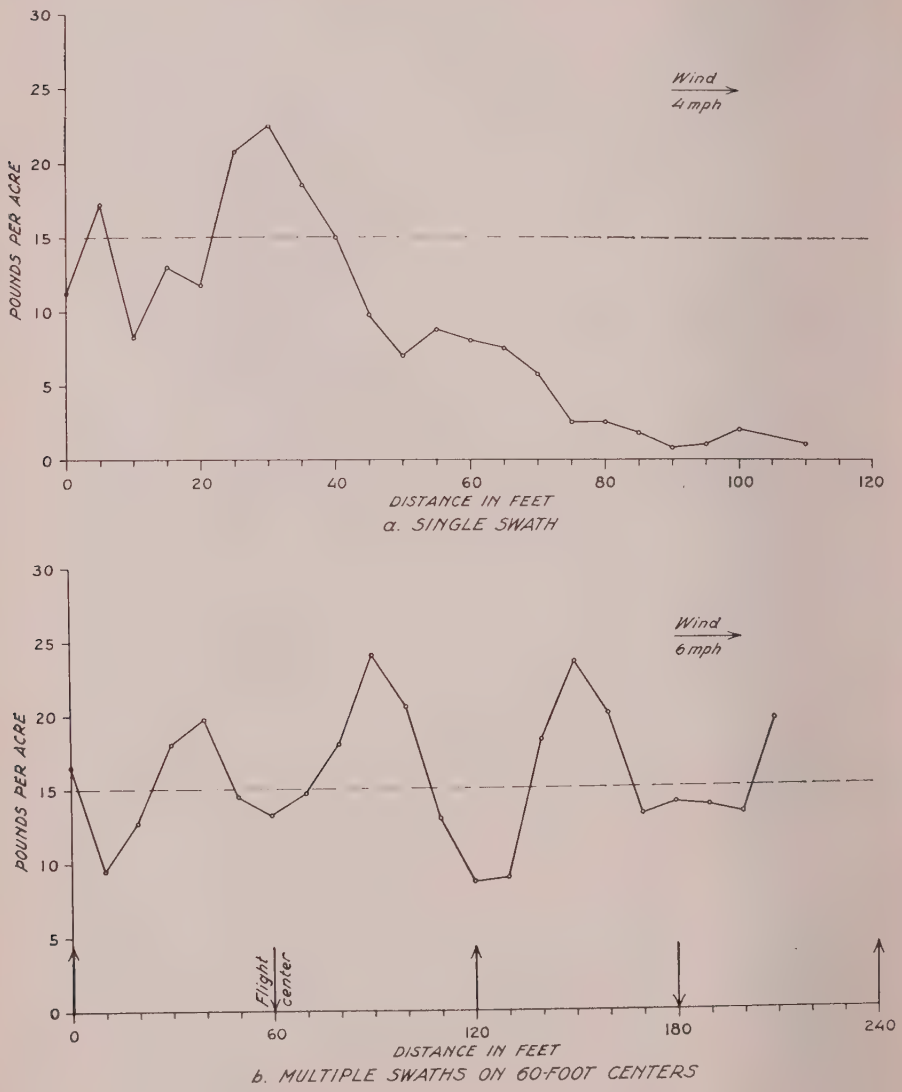

FIG. 1.—Typical dosage curves with granular paris green using a Swathmaster distributor mounted on a 450 h.p. Stearman airplane.

(Walk.) using the 450 h.p. Stearman equipped with the Swathmaster distributor. All tests were flown on 60-foot flight centers and at an altitude of 40 feet above the highest horizontal surface. Plots varied in size from 5.5 to 17.6 acres and were in typical mangrove-pickleweed salt marshes in Indian River County, Florida. Treatments were applied at various times throughout the day, some when ground

winds were estimated to be 15 to 20 miles per hour. Since complete coverage is so important with this stomach-poison larvicide, a gross coverage of 15 pounds per acre was used in all tests and toxicant dosage was controlled by varying the concentration of paris green in the formulation. Treatments were replicated in time and in space, in order to include as much variability of marsh features as possible for each treatment.

Dispersing runs were all flagged at each end of the run in all plots. Treatments and results are shown in Table 3.

TABLE 3.—Test results with granular paris green larvicide applied by airplane against *Aedes taeniorhynchus* (Wied.) and *Aedes sollicitans* (Walk.)

Formulation-% paris green	lb./a of toxicant [1]	Number of tests	Avg. No. larvae per dip		Percent reduction	Range
			Pretreatment	24 hours		
5	0.75	3	94.9	1.6	98.3	97.1–100
2–1/2	0.375	3	69.1	0.1	99.9	99.8–100
1–1/4	0.1875	1	75.5	28.0	62.9	——

[1] All treatments applied at a rate of 15 lbs. per acre gross.

Results shown in Table 3 indicate no significant differences in larval kill between .75 and .375 pounds per acre of paris green. The slightly lower percent reduction shown for the higher dosage actually does not represent poorer average larval kill throughout the treated area. In the plots treated with .75 pound per acre, 270 live larvae from a total of 324 found at 24 hours were counted in two dips from the same dipping station. A vertical obstruction in the marsh apparently diverted most of the larvicide from this station. No other live larvae were found in this 10-acre plot where the population averaged 243 per dip before treatment. Unfortunately, opportunity did not permit more than one test with the 1-1/4 percent formulation, but this test probably serves adequately to indicate that .375 pound per acre was near the minimum effective dosage in these tests.

DISCUSSION

The formula recommended in this paper for granular paris green to be applied from the air is a balanced formula requiring those specifications and materials outlined, or equivalents. The specified amount of emulsifiable oil, for example, on a hundredweight basis might be too large or too small a quantity if a different grade of vermiculite is used, making the finished formulation too oily or too dry. Therefore it is suggested that nonequivalent substitutions of materials be accepted only after adequate demonstrations of their effective use, both physically and biologically.

The most effective and economical operation with this larvicide in any given locality with regard to toxicant dosage, gross poundage for adequate coverage, effective swath, etc. probably can best be determined locally as these factors relate to local marsh conditions, available equipment, etc. It seems pertinent, however, to reemphasize certain factors that appear to be important in the successful use of this larvicide, whether applied at ground level or by airplane. Paris green apparently acts only as a stomach toxicant to mosquito larvae; therefore its effectiveness is directly related to the degree of coverage in application. This assumes, of course, that the particular mosquito species in question is one that can be controlled with paris green. It has been tested against only a few species of culicine mosquitoes, and its effectiveness against other species is yet to be determined.

During approximately 24 years of intensive, worldwide use as a mosquito larvicide prior to 1945, there was recorded for paris green an excellent record of safety for fish, wildlife, domestic animals, and man. The new granular formulation is

especially easy to apply and appears to present a minimum of hazard to mosquito control personnel.

Although history cannot in this instance be used as a basis to predict future performance with regard to the resistance problem, it does seem worthy of present note that no anopheline species was reported to become resistant to paris green during its long and intensive use in malaria control. It can be stated with confidence that granular paris green is currently very effective for controlling salt-marsh *Aedes* that are resistant to chlorinated hydrocarbon insecticides in Florida.

References

ROGERS, ANDREW J. and RATHBURN, CARLISLE B., JR. 1958. Tests with a new granular paris green formulation against *Aedes, Anopheles,* and *Psorophora* larvae. Mosquito News 18(2):89–93.

———. 1960. Improved methods of formulating granular paris green larvicide. Mosquito News 20(1):11–14.

PAST, PRESENT AND FUTURE IN INSECTICIDE-RESISTANCE OF MOSQUITOES *

A. W. A. BROWN

Head, Department of Zoology, University of Western Ontario, London, Canada

It is now 15 years since DDT was introduced as a powerful agent for mosquito control. At half-time, that is 7 to 8 years ago, the insecticide-resistance situation was summarized by Hess, in his two review papers. The salt-marsh mosquitoes of Florida were DDT-resistant in treated areas, but still susceptible to BHC or dieldrin. The irrigation-water *Aedes* of California had become DDT-resistant in treated areas, while the *Culex* were becoming resistant to BHC and the cyclodiene group of insecticides. *Culex pipiens* in central Italy had added chlordane-resistance to DDT-resistance, while a decline in DDT-susceptibility of this species had been noted at Toledo, Ohio. There was no real DDT-resistance in *Anopheles,* limited to slight changes in *A. quadrimaculatus* in Alabama and Florida, premonitions in *A. sacharovi* in Greece, and behavioral changes in *A. albimanus* in Panama.

Now, after the lapse of a further 7 to 8 years, the resistance picture in mosquitoes has become much more serious, particularly in *Anopheles* (Table 1). No less than 21 species in this genus have now developed resistance to one or more of the chlorinated hydrocarbons used as adulticides on the walls of buildings. Of this number 7 species have developed resistance to DDT, and 20 to dieldrin. In fact, *A. sundaicus* is the only species in which DDT-resistance alone has been developed; all the others have developed dieldrin-resistance in different populations or in the DDT-resistant population itself. Dieldrin-resistance is strikingly intense, so that there is no doubt about it. For example, we all remember the question whether *A. quadrimaculatus* had developed DDT-resistance in the southeast; by the time it was decided that it was a local slight increase in tolerance, intense dieldrin-resistance had developed in Mississippi. The Greek *A. sacharovi,* whose increased DDT-tolerance took such a long time to prove, now shows strong dieldrin-resist-

* Invitation Paper on the Special Topic of Insecticide Resistance, 16th Ann. Mtg., 1960.

TABLE 1.—Resistance to DDT and dieldrin by anopheline mosquitoes.*

DDT	*A. sacharovi*	1951, Greece, Lebanon, Iran, Turkey
	A. sundaicus	1954, Java, Burma
	A. stephensi	1955, Arabia, Iraq, Iran, S. India
	A. subpictus	1955, North India, W. Pakistan
	A. albimanus	1958, Salvador, Nicaragua, Guatemala, Honduras
	A. pharoensis	1959, Egypt
	A. quadrimaculatus	1959, Georgia, Maryland, Mexico
Dieldrin	*A. sacharovi*	1952, Greece
	A. quadrimaculatus	1953, Mississippi, Maryland
	A. gambiae	1955, Nigeria, Liberia, Ivory Coast, Upper Volta, Dahomey, Cameroun, Sierra Leone
	A. subpictus	1957, Java, Ceylon, N. India
	A. coustani & *A. pulcherrimus*	1957, Arabia
	A. albimanus	1958, Salvador, Guatemala, Nicaragua, Honduras, Jamaica, Ecuador, Mexico, Br. Honduras, Cuba, Dominican Rep.
	A. pseudopunctipennis	1958, Mexico, Nicaragua, Peru
	A. aquasalis	1958, Trinidad, Venezuela
	A. culicifacies	1958, E. India
	A. vagus	1958, Java, Philippines
	A. barbirostris & *A. annularis*	1958, Java
	A. sergenti	1958, Jordan
	A. fluviatilis	1958, Arabia
	A. stephensi	1959, Iran
	A. minimus flavirostris	1959, Philippines
	A. pharoensis	1959, Egypt
	A. albitarsis	1959, Colombia
	A. labranchiae	1959, Morocco

* Date given is first year of occurrence.

ance. The Mexican *A. pseudopunctipennis,* which had not lost any of its DDT-susceptibility in over 10 years of DDT spraying, went resistant to dieldrin within a few months of its introduction in the state of Morelos. The development of dieldrin-resistance in already DDT-resistant populations of *A. stephensi* around the Persian Gulf presents a most serious setback to the world-wide malaria eradication program, as does the presence of high DDT-tolerance in the dieldrin-resistant populations of *A. albimanus* in Central America. More than 5 percent of the eradication program is now confronted with resistant *Anopheles,* and this gap in the protective umbrella of insecticides is becoming larger.

In addition to physiological resistance, where populations have come to survive a lethal dose, there is behavioristic resistance, where populations have come to avoid taking up a lethal dose. Behavioristic resistance may be of two types. One is exemplified by *A. albimanus* in Panama, which derives from a hyperirritable response to DDT which causes them to leave the deposit prematurely; the other is exemplified by *A. cruzii* in southern Brazil and *A. punctimacula* in Colombia, populations of which have developed the behavior of resting outside instead of inside houses. The matter of behavioristic resistance, however, demands more exact study before it can be characterized adequately.

No less than 14 species of culicine mosquitoes have developed resistance to DDT or other insecticides (Table 2). The worst problem is the tropical house mosquito, against which the chlorinated hydrocarbons have been applied as larvicides as well as adulticides. This *Culex quinquefasciatus,* or *C. fatigans* as which it remains more generally known, is coming to rival the house fly in that there are now few parts of the world where it has not increased its natural DDT-tolerance to palpable DDT-resistance, or developed resistance to BHC, dieldrin, chlordane or toxaphene. DDT-resistance has developed

TABLE 2.—Resistance to three insecticide groups by culicine mosquitoes

	DDT group	BHC-Dieldrin gp.	Organophosphorus gp.
Culex fatigans (quinquefasciatus)	India 52, Reunion 53 Venezuela, Taiwan 56 Puerto Rico 57 S. Australia, Panama 58	Cal. 51, Malaya, India 53, E. Asia 54 S. America 56 W. Africa 57 Panama 58 Zanzibar 59	Cameroun 59
C. pipiens	Italy 47, Mass. N. J. 55, Japan, Cal. 59	Italy 50, Israel 55 France, Japan 59	
C. tarsalis	Cal. 51, Ore. 56	California 51	California 56
C. coronata	Panama 58		
C. poicilipes, C. nebulosus, C. tritaeniorhynchus		Dahomey 59	
Aedes aegypti	Trinidad, Dominican Rep. 54 Venezuela 55, Haiti 56 NE Colombia 57 Puerto Rico, Jamaica, Guadeloupe 59	Puerto Rico 59	
A. sollicitans	Fla. 47, Del. 51	Fla. 51, Del. 59	Florida 52*
A. taeniorhynchus	Florida 49	Florida 51, Ga. 59	Florida 52*
A. nigromaculis	California 49	California 51	California 58
A. dorsalis	California 51	California 51	
Psorophora confinnis, P. discolor		Mississippi 54	

* Slight increase, of 4–10 times the normal LC_{50}.

in another species of *Culex* in Panama, and dieldrin-resistance in 3 species in Dahomey. The DDT-resistance of *C. tarsalis* has spread from California to northwestern Oregon, but not to Utah. This species is increasing its dieldrin-tolerance in Weber County, Utah, and its heptachlor-tolerance at Eugene, Oregon. DDT-resistant larvae of *C. pipiens* have been discovered in testing surveys in parts of Massachusetts, New Jersey and California but evidently have not developed into a problem in Ohio or Illinois. Dieldrin-resistant larvae of this species have developed in Jerusalem, Israel, at Narbonne, France and are suspected at certain points in Massachusetts; while larvae of the variety *C. pipiens pallens* have been reported to have become resistant to chlorinated hydrocarbons at Nawasaki city, Japan.

The DDT-resistance of the salt-marsh *Aedes* larvae of Florida was very soon supplemented by resistance to the other chlorinated hydrocarbons such as BHC and dieldrin. A type of dieldrin-resistance with some cross-resistance to DDT was recently discovered in *A. taeniorhynchus* in Chatham County, Georgia. The increased tolerance of DDT that developed in *A. sollicitans* in Sussex County, Delaware, could be gradually lost if this insecticide was discontinued or substituted; however, BHC-resistance has developed in Kent County in 1959. In more northern regions the slow voltinism and high dilution factor from surrounding untreated areas evidently account for the absence of resistance, as found in a survey of *Aedes canadensis* and other species made in southern Ontario in 1953. Meanwhile, agricultural insecticides are evidently maintaining the resistance of the irrigation-water *Aedes* and *Culex* in California, since it is just as strong outside the Abatement Districts as inside them. A reduced susceptiblity to both DDT and dieldrin was detected in *A. dorsalis* in Salt Lake County, but otherwise there has been no change in the *Aedes* larvae of Utah.

A strong dieldrin-resistance, with no cross-resistance to DDT, developed in the rice-field mosquitoes *Psorophora confinnis* and *P. discolor* in Bolivar County, Mississippi, just one year after dieldrin was applied to control them. It was suggested that perhaps cotton insecticides had predisposed these populations to develop the resistance so rapidly.

In 1954 it became evident that a strong DDT-resistance had developed in certain parts of Trinidad in larvae of the yellow-fever mosquito, *Aedes aegypti*. This DDT-resistance has been subsequently found elsewhere in the Caribbean area and in the northern states of South America. Last year a most serious development was discovered; at Isla Verde, near San Juan, Puerto Rico, larvae of *A. aegypti* had become strongly resistant to dieldrin as well as to DDT.

Resistance to the organophosphorus compounds which have been substituted as mosquito larvicides is now developing in certain areas. Malathion-resistance first developed in the *Culex tarsalis* of Fresno County, California. Next, parathion-resistance was discovered in the *Aedes nigromaculis* of Kings and Tulare counties. Increased tolerances to malathion and EPN have already been reported for the salt-marsh mosquitoes in Brevard County, Florida. Recently malathion-resistance has developed in larvae of *Culex fatigans* at Duala, Cameroun.

The recognition of resistance as an ingredient of control failures became possible with the appearance of consistent test methods for susceptibility levels. Now the tests for adult mosquitoes and mosquito larvae have been standardized on a world-wide basis, and test kits are available and have been widely distributed. The application of these tests and the use of these kits in recent years has played an essential part in telling us just how far resistance has developed in vector control programmes. These tests have also proved themselves valuable tools for the more basic genetical and biochemical studies of resistance conducted in the world's laboratories. The role of WHO (The World Health Organization) in these developments is probably familiar to most of us.

In assessing the future, we must first be sure to have a correct understanding of the fundamentals of the resistance phenomenon. It does not derive from increased adaptation during the lifetime of the insect; exposure to multiple harmless doses does not increase the tolerance of that individual to the insecticide. It derives from selection of the normally more tolerant individuals in the population, and therefore requires the mortality of the more susceptible elements. In no case has it proved possible to induce resistance without mortality in the strain. Insecticide-resistance is a Darwinian phenomenon, and derives from the pre-adaptation to resistance already existing in a small segment of the population.

These pre-adaptations are due to genes. It was first found that dieldrin-resistance was inherited in *Anopheles gambiae* as if it was due to a single gene, allelic with the normal and without dominance. Similarly DDT-resistance in *Aedes aegypti* was found to be due to a single gene allele without dominance, the F_1 heterozygotes being intermediate in resistance. DDT-resistance in *Anopheles sundaicus* was found to be explicable by a single recessive gene. The allele for dieldrin-resistance of *Anopheles gambiae* was found to pre-exist in untreated areas in the interior of West Africa, where between 0.05 and 12 percent of these mosquitoes were heterozygous for it. One cycle of dieldrin spraying could transform such populations so that they comprised approximately 90 percent resistant homozygotes. The resistance hazard of a species, then, depends on whether it contains some individuals carrying the appropriate resistance gene. Attempts to evaluate this hazard by submitting laboratory colonies to insecticide pressure have been of limited value because they tested only a fraction of the gene pool of the species. It is a truism to say that a species is susceptible because it contains few or no resistant genotypes. The reason that the resistant genotypes

are normally scarce is because they have a lower survival rate than the susceptible ones in insecticide-free conditions. We have obtained a laboratory demonstration of this fact in a Malayan strain of *Aedes aegypti* which rapidly develops DDT-resistance under selection pressure but as rapidly loses it under DDT-free conditions.

Field experience and the performance of tests for cross-resistance have shown that DDT-resistance is separate from dieldrin-resistance in mosquitoes, as in house flies and many other insects. DDT-resistance extends to its analogues methoxychlor and DDD; dieldrin-resistance extends to other cylodiene derivatives such as chlordane, heptachlor and toxaphene, and also rather surprisingly to gamma-BHC. As to the mechanism of DDT-resistance in mosquitoes, it is still an open question whether it is related, as it is in the house fly, to its detoxification by dehydrochlorinase to DDE. The mechanism of dieldrin-resistance remains a mystery even in house flies; at least the associated BHC-resistance of *Anopheles gambiae* was not correlated with an increased detoxification or decreased cuticular absorption. It is however known that an increase in the fat body of adult *Anopheles maculipennis* will greatly increase their dieldrin-tolerance. With regard to malathion-resistance, we have obtained laboratory evidence with *Culex tarsalis* larvae that it is correlated with a lower level of the toxic metabolite malaoxon and a greater production of non-toxic water-soluble derivatives, much as has been found in the house fly.

There is yet another type of resistance; this is a non-specific vigor tolerance extending to insecticides in general. Characteristically it develops slowly and does not reach very high levels; genetically it derives from accumulation of multiple genes of non-specific and comparatively slight effect. It is probable that the changes formerly observed for *A. quadrimaculatus* with DDT in Alabama may have been of this nature. Another member of the *maculipennis* group, namely *A. sacharovi,* has reached a plateau of DDT-tolerance in Greece, where DDT is still moderately effective. It is extremely important to know whether any changes detected by susceptibility test indicate vigor tolerance or incipient true resistance. If the dosage-mortality lines remain parallel as they move to the right, and if similar increases in LC_{50} are shown to different insecticides, the probabilities are that it is a case of vigor tolerance. If on the other hand the d-m line becomes shallower in slope, or even more becomes flat at the higher concentrations, true resistance is indicated.

In a number of species there now exist populations which simultaneously show high dieldrin-resistance and moderate DDT-tolerance, e.g. *Anopheles albimanus* in central America, *An. sacharovi* in Greece, *An. quadrimaculatus* in Maryland, and *Aedes aegypti* in Puerto Rico. We have been attempting to separate the dieldrin-resistance from the DDT-resistance in the Puerto Rico strain by a combination of back-crossing and pressure from one or other of the insecticides; we find that the two resistances remain as a single entity, and are probably due to a single gene on chromosome 2. Microscopical examination of the chromosomes themselves is much more difficult in *Aedes* than in *Anopheles;* although certain chromosome inversion types have been associated with DDT-tolerance in *Anopheles atroparvus,* it is by no means clear whether they have anything to do with specific DDT-resistance.

The cross-resistance pattern dictates the choice of substitute insecticides. As a general rule, mosquitoes that have become DDT-resistant as a result of DDT pressure remain susceptible to dieldrin or BHC. Indeed the DDT-resistant *An. sundaicus* in northern Java have remained susceptible to dieldrin for several years. But DDT-resistance predisposes many species of mosquitoes to a rapid development of dieldrin-resistance, as was the experience with *Aedes* and *Culex* in California and Florida, with *An. sacharovi* in southern Greece and *An. stephensi* in southeastern Iran. Sometimes the dieldrin-

resistance of adult *Anopheles* forces a return from dieldrin to high doses of DDT, as in Greece and also in *An. albimanus* in El Salvador. For control of culicine larvae, certain OP compounds have been substituted. It is cold comfort to know that the OP-resistances now developed in *Culex tarsalis* and *Aedes nigromaculis* are specific to malathion and parathion respectively, without cross-resistance between the two compounds. However, we have developed by laboratory selection a malathion-resistant strain of *Aedes aegypti* which, like the house fly in similar circumstances, has a cross-tolerance to the carbamate Sevin and a very high cross-resistance to DDT.

And so we go marching on, making things more difficult for ourselves. Is there anything we can do to throw resistance into reverse? If we can find compounds whose cross-resistance is negatively correlated with DDT, we can expect that the more DDT-tolerant survivors of a DDT selection will be more susceptible than normal to this compound. Vice versa, the survivors from selection with this compound will be the more DDT-susceptible individuals, and so the compound should be able to restore DDT-susceptibility to a heterogeneous DDT-resistant strain. Such negatively-correlated compounds have cropped up from time to time for house flies or *Drosophila.* DTP, an organophosphorus preparation, was one for house flies; but attempts to repeat the results met with failure. CBA (cetyl bromoacetate) was another for house flies, but this negative correlation was not found in experiments on field strains. Apparently CFA (cetyl fluoracetate) has given better results, on *Anopheles* larvae as well as house flies. PTU (phenylthiourea) is a good one for *Drosophila,* since PTU-susceptibility is tied to the same gene as DDT-resistance and vice versa; unfortunately PTU is non-toxic to house flies. We have tested PTU, CBA and CFA in our own laboratory on various strains of *Aedes aegypti* with the following results: CFA has shown no negative correlation with DDT-resistance, while CBA and PTU are not larvicidal. Despite all these disappointments, negatively-correlated compounds offer at present our only hope of throwing resistance in reverse, and we should continue to look for them by empirical testing or by basic biochemical research.

As we peer into the future, we can only hope that such compounds will appear. Meanwhile we can hang on and make the most of what we have. The basic principle is to practice economy. Economy in extent of the area treated will reduce the resistance hazard by leaving a greater proportion of untreated population to dilute the resistant genotypes left in the treated area. Economy in choice of insecticide means avoiding a premature switch to a substitute insecticide until susceptibility tests with the standard insecticide indicate it is absolutely necessary; thus we can delay our passage from one insecticide-resistance to the next. Taking a hint from cockroach control, we can return to certain older, less effective insecticides that do not have a record of resistance, such as paris green for *Psorophora* control in Florida, and Thanite for *Culex* control in Egypt. More stress will be laid on environmental and biological means of control, even though the former will be more expensive and the latter less effective than the use of insecticides. The susceptibility levels of populations under treatment will be followed and their cross-resistances probed, while more basic research will investigate origins and mechanisms of resistance. Those responsible for management will thus be sufficiently well-informed that their anti-mosquito operations will avoid the errors of rigidity on the one hand and panic on the other. In these ways we can buy time to continue the search for definite means of counteracting resistance.

SUSCEPTIBILITY LEVELS OF SOME *AEDES AEGYPTI* (LINN.) LARVAE TO DDT AND DIELDRIN

BURTON R. EVANS,[1] JOHN E. PORTER,[2] GEORGE KOZUCHI,[2] AND EDWARD J. FINK [1]

There is always need to study periodically the results of measures used for mosquito control. The authors thought it advisable, therefore, to establish a base line of the susceptibility of *Aedes aegypti* (Linn.) larvae to the insecticides at present used by various control groups, one of which is the *A. aegypti* detection and control program conducted by the Public Health Service Quarantine Stations in international traffic areas.

During 1959 tests were made by personnel of the New Orleans, Louisiana, and Miami Beach, Florida, Quarantine Stations to determine the susceptibility levels of *aegypti* larvae to DDT. Additional tests at New Orleans were made to study the susceptibility levels of dieldrin. World Health Organization larval test kits were used in these studies.

Confirmed resistance to DDT in *aegypti* has been reported in several parts of South America and the Caribbean area; these include Haiti, Venezuela, Colombia, Dominican Republic, and Trinidad. Schoof (1959) reported that a Trinidad strain had an LD-50 of 4.00 p.p.m. of DDT. Gilkes and others (1956) found that a colony of *aegypti* established from a local Trinidad area had only a 66.5 percent mortality of larvae in 10.00 p.p.m. of a DDT emulsion. These local *aegypti* had been exposed to DDT for about 9 years. No resistance to DDT has been reported for *aegypti* in the United States.

No reports to date have been found of *aegypti* resistance to dieldrin.

The Communicable Disease Center was reported to have used DDT for the control of *aegypti* larvae in New Orleans during 1945–46. This material has been used by the City Health Department as a general larvicide and adulticide from 1949 to date. Some of these applications were made by helicopter in 1951 (Gardner and Winklmeir, 1960). The PHS Quarantine Station in New Orleans has used DDT as an *aegypti* larvicide in its control program in international dock and airport areas since 1958.

DDT has been used generally as an adulticide and larvicide in Miami, Florida, and the surrounding metropolitan area since 1946 (Stutz, 1960). During this time it is doubtful if over half of the city has been regularly exposed (i.e. during pest mosquito outbreaks) to aerial distribution of DDT. Larviciding with emulsifiable DDT for the control of *aegypti* is an established adjunct to the Mosquito Division, Dade County, Florida; this material is also used by the PHS Quarantine Station in Miami Beach.

Dieldrin apparently has not been used in mosquito control work in New Orleans or Miami (Gardner and Winklmeir, 1960; Stutz, 1960).

METHODS AND MATERIALS. The World Health Organization larval resistance kit was used according to its recommendations (WHO, 1958; WHO, 1959). A total of 16 replicates with 10 to 15 larvae for each concentration was used with DDT and dieldrin for *aegypti* larvae from New Orleans. A total of 46 replicates with 10 to 25 larvae for each concentration was used with DDT for *aegypti* from Miami. Water temperatures ranged within the acceptable limits of 20° to 30° C. Tests with controls having over a 20 percent mortality or a 10 percent pupation were discarded. Where the control mortality was between 5 and 20 percent, the percentage mortalities were corrected by Abbott's formula:

[1] Quarantine Station, Public Health Service, Department of Health, Education, and Welfare, New Orleans, Louisiana.

[2] Quarantine Station, Public Health Service, Department of Health, Education, and Welfare, Miami Beach, Florida.

$$\frac{\%\text{ test mortality} - \%\text{ control mortality}}{100 - \%\text{ control mortality}} \times 100$$

The *aegypti* larvae in New Orleans were collected from fire barrels in a cotton warehouse in the international dock area. The first eight replicates using DDT were from field-collected larvae; the last eight replicates came from a colony established from the field collections since enough larvae in the field were not available to complete the tests. All of the larvae for the dieldrin tests came from this colony.

The use of a colony should usually be avoided where possible due to unknown factors in selectivity. The use of the colony in this study through about ten generations is believed not to have appreciably affected the results since there was little change in susceptibility during the tests. The LD-50 from the first four DDT replicates and the last four had a difference of .003 p.p.m. The fifth through about the tenth generation of the *aegypti* colony was used to complete the 16 dieldrin replicates. The LD-50 from the first and last four replicates had a difference of only .0009 p.p.m.

The *aegypti* larvae in Miami were field-collected from the Miami River waterfront area for the first ten replicates. Larvae from the same general area were reared in the laboratory for one generation for each of the last 36 replicates.

The percent mortalities recorded in the tables were used on a probit log chart for determining the LD-50 (Swaroop and Uemura, 1956).

Results. In Tables 1 and 2 the results of the resistance tests on *aegypti* from New Orleans and Miami using DDT and dieldrin are summarized. The WHO indicates that from the small amount of data available at present, where the LD-50 for DDT exceeds .1 p.p.m. for *Aedes* larvae, resistance should be suspected (WHO, 1959).

The New Orleans *aegypti* had an LD-50 of 0.013 p.p.m. for DDT, and an LD-50 of 0.002 p.p.m. for dieldrin from the data recorded on Table 1. From the percent

TABLE 1.—Susceptibility levels of *Aedes aegypti* larvae from New Orleans, Louisiana, to DDT and dieldrin after 24 hours

Concentration of insecticide in test suspensions	Total no. of larvae used		Total no. of dead and moribund larvae		Percent mortality	
	DDT	Dieldrin	DDT	Dieldrin	DDT	Dieldrin
.0008 p.p.m.	—	213	—	29	—	14
.0024 p.p.m.	—	176	—	101	—	57
.004 p.p.m.	172	210	51	178	25	85
.02 p.p.m.	166	212	92	210	52	99
.1 p.p.m.	175	—	169	—	95	—
.5 p.p.m.	182	—	182	—	100	—
Control	168	210	10	7	5.9	3

TABLE 2.—Susceptibility levels of *Aedes aegypti* larvae from Miami Beach, Florida, to DDT after 24 hours

Concentration of insecticide in test suspensions	Total no. of larvae used	Total no. of dead and moribund larvae	Percent mortality
.004 p.p.m.	1005	27	3
.02 p.p.m.	1003	101	10
.1 p.p.m.	1003	620	62
.5 p.p.m.	1009	941	93
Control	1004	9	0.9

mortalities recorded on Table 2 for Miami Beach *aegypti,* an LD-50 of 0.07 p.p.m. was found for DDT.

On the basis of these studies, the New Orleans *aegypti* larvae were highly susceptible to DDT and to dieldrin. No resistance to these chemicals is indicated.

The Miami *aegypti* appear to have a very low susceptibility to DDT. It took more than five times as much insecticide in Miami to get an LD-50, as it did in New Orleans. Even with .5 p.p.m. of DDT only 93 percent of the population was killed. This suggests that 7 percent of the population may be resistant to this concentration of DDT. While the Miami *aegypti* are not declared resistant to DDT, there is some evidence that resistance may be developing.

Bibliography

GARDNER, W. P. and WINKLMEIR, A. 1960. Personal communication. Director, New Orleans Health Department, and Director, Division of Pest and Rat Control, New Orleans Health Dept. respectively, New Orleans, Louisiana.

GILKES, C. D., KELLETT, F. R. S., and GILLETTE, H. P. S. 1956. Yellow fever in Trinidad and the development of resistance in *Aedes aegypti* Linn. to DDT formulations. West Ind. Med. Jour. 5(2): 73–89.

QUARTERMAN, K. D. and SCHOOF, H. F. 1958. The status of insecticide resistance in arthropods of public health importance in 1956. Amer. Jour. Trop. Med. & Hyg. 7(1):74–83.

SCHOOF, H. F. 1959. Resistance in arthropods of medical and veterinary importance—1946–58. Misc. Publ. of the Ent. Soc. of Amer. 1(1):3–11.

STUTZ, F. H. 1960. Personal communication. Director, Dade County Mosquito Control Division, Miami, Florida.

SWAROOP, S., and UEMURA, K. 1956. Probit analysis in the assessment of susceptibility of anophelines to insecticides. World Health Organization. Statistical Studies Section. 32 pp.

WORLD HEALTH ORGANIZATION. 1958. Insect resistance and vector control. World Health Organization. Technical Report Series No. 153. 68 pp.

WORLD HEALTH ORGANIZATION. 1959. Instructions for determining the susceptibility or resistance of mosquito larvae to insecticides. 4 pp.

CROSS-RESISTANCE CHARACTERISTICS OF A MALATHION-TOLERANT STRAIN DEVELOPED IN *AEDES AEGYPTI*

A. W. A. BROWN AND Z. H. ABEDI
University of Western Ontario, London, Canada

The control of *Aedes aegypti* by chlorinated hydrocarbons has encountered DDT-resistance in several parts of the Caribbean area, and dieldrin-resistance has also appeared in Puerto Rico. Fortunately the typical DDT-resistant strain from Trinidad proved to be only slightly less susceptible than normal to malathion (Fay, 1956; Abedi & Brown, 1960). But since malathion-resistance has developed in larvae of *Culex tarsalis* in California (Gjullin & Isaak, 1957), it became important to ascertain whether *Aedes aegypti* larvae would develop this resistance under selection pressure from malathion in the laboratory.

A strain originating from Penang, Malaya, and kindly supplied to us by the Army Chemical Center, Maryland, was submitted to malathion pressure for 8 generations in the laboratory. This strain was chosen because it had already shown itself capable of developing DDT-resistance under pressure, and thus probably had a greater genetic variability than most laboratory strains of *Aedes aegypti.* Selection pressures in excess of 90 percent mortality were applied with malathion to maturing larvae of the parental, F_2, F_4, F_6 and F_7 generations. The resulting larval susceptibility levels were assessed by the standard W.H.O. method (Brown, 1958).

The results are shown in Table 1. The tolerance levels to malathion increased steadily, to become 4 to 5 times the normal in the F_8 generation. Since a parallel non-selected strain showed during this period a slight drop in the LC_{50} from 0.30 down to 0.23 p.p.m. malathion, the difference between the selected and control strains was actually 6-fold.[1]

developed to DDD (TDE), indeed slightly more than to DDT, whereas with respect to methoxychlor there was only a 3-fold increase in tolerance.

This malathion-tolerant DDT-resistant strain showed little or no change from the normal in its susceptibility to dieldrin or heptachlor. However, the malathion selection did succeed in raising the BHC-

TABLE 1.—Larval LC_{50} levels in p.p.m. of the Penang strain of *Aedes aegypti* submitted to malathion pressure in the P_1, F_2, F_4, F_6 and F_7 generations

Generation	Malathion	Sevin	DDT	DDT*
P	0.30	1.93	0.08	0.08
F_1	0.62	——	——	0.10
F_2	0.62	2.05	1.08	0.82
F_3	0.68	3.7	——	——
F_4	0.82	——	——	——
F_6	1.05	4.4	——	——
F_7	1.28	——	1.8	——
F_8	1.40	9.1	2.5	——

* Repeat selection with malathion in the P & F_1 generations.

It was of interest to ascertain whether this malathion pressure induced a parallel cross-resistance to the carbamate Sevin and to DDT itself. It is seen in Table 1 that the cross-tolerance to Sevin increased slowly at first but later increased to 5 times the normal. The cross-resistance to DDT increased to over 30 times the normal, showing an abrupt rise between the F_1 and F_2 generations.

The cross-tolerance characteristics of the malathion-selected F_8 generation were then assessed with respect to other OP compounds, other carbamates, certain analogues of DDT, and the BHC-cyclodiene group of insecticides (Table 2). It was found that the tolerance of parathion and of diazinon had been scarcely increased by the malathion pressure. The carbamate insecticides Pyrolan and Dimetilan were insufficiently larvicidal; but it could be ascertained that the tolerance of isopropyl-phenyl-methyl-carbamate, a typical member of the group, increased much less than that of Sevin. A high cross-resistance had tolerance of the Penang strain, which was initially rather high, by 2–3 times. It may well be asked what kind of malathion-resistance has been produced in this strain of *Aedes aegypti*. True malathion-resistance, such as was discovered in the *Culex tarsalis* of Fresno County, California, shows an increase in larval LC_{50} of about 30 times (Gjullin & Isaak, 1957). However, an increase in larval LC_{50} of 2–3 times proved sufficient to result in an observable resistance of *Aedes nigromaculis* to control with parathion in Kings and Tulare Counties (Lewallen & Brawley, 1958; Lewallen & Nicholson, 1959). On the other hand, a cross-resistance of 4 times the normal to EPN and 10 times the normal to malathion in the salt-marsh *Aedes* mosquitoes of Cocoa Beach, Florida, has passed without special comment (Keller & Chapman, 1953).

The question whether the results of malathion pressure here obtained represent increased vigor tolerance or true resistance can be illuminated not only by the cross-resistance data but also by the dosage-mortality regression lines of the successive generations. The criterion proposed by Hoskins & Gordon (1956) is that strains

[1] A subsequent selection in the F_8 did not change the LC_{50}, which remained stable at 1.40 in the unselected F_{10} and F_{11}.

TABLE 2.—Larval LC_{50} levels in p.p.m. of the normal Penang strain of *Aedes aegypti* and a malathion-resistant substrain in the F_8 generation

	Normal	Resistant		Normal	Resistant
Malathion	0.26	1.43	DDT	0.08	2.56
Parathion	0.035	0.055	Methoxychlor	0.14	0.40
Diazinon	0.12	0.17	DDD	0.32	14.0
Sevin	1.9	9.1	Dieldrin	0.028	0.034
Pyrolan	No kill up to 50		Heptachlor	0.023	0.023
Dimetilan	No kill up to 128		gamma-BHC	0.23	0.56*
3-Isopropylphenyl-N-methyl-carbamate				0.19	0.29

* F_7 Generation tested. † Kindly supplied by H. H. Moorefield, Boyce Thompson Institute.

on the way to true resistance show an initial flattening of the d-m line, whereas with vigor tolerance these lines stay parallel. It will be seen (Fig. 1) that the regression lines with malathion remain

With the cross-resistances to isopropylphenyl-methyl-carbamate, dieldrin, gamma-BHC and methoxychlor (Fig. 3), the d-m lines remain parallel or flatten slightly. With heptachlor there is no change in the

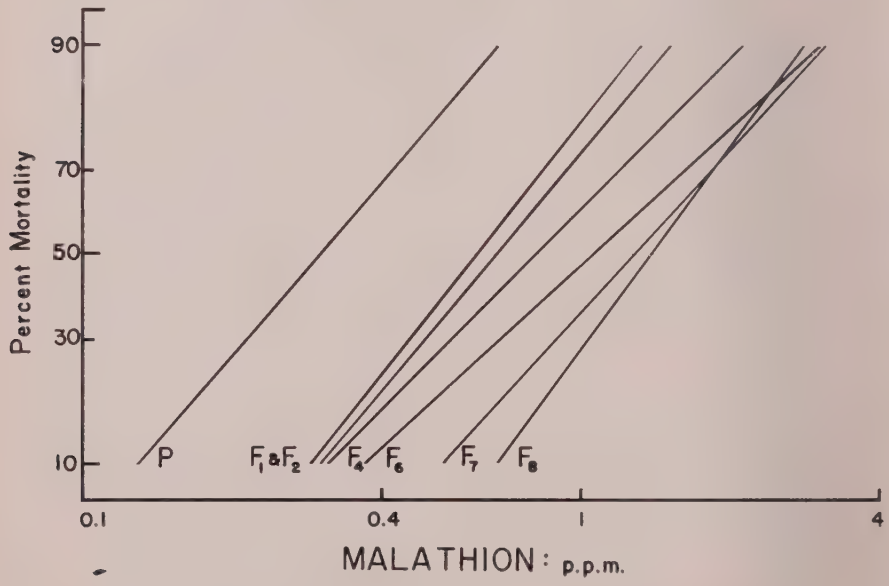

FIG. 1.—Dosage-mortality lines for malathion shown by successive generations.

roughly parallel in their movement towards resistance to the right, although there is a slight flattening between the F_4 and F_7 generations. The d-m lines for the cross-resistance to Sevin however stay almost completely parallel (Fig. 2), although there is a slight progressive decrease in slope.

line at all. With parathion the regression line flattened very slightly; but with diazinon it steepened, pivoting about the highest mortality, as if only the susceptible genotypes had been eliminated without any more tolerant genotypes appearing.

Most dramatic changes in the d-m lines appear with the development of cross-

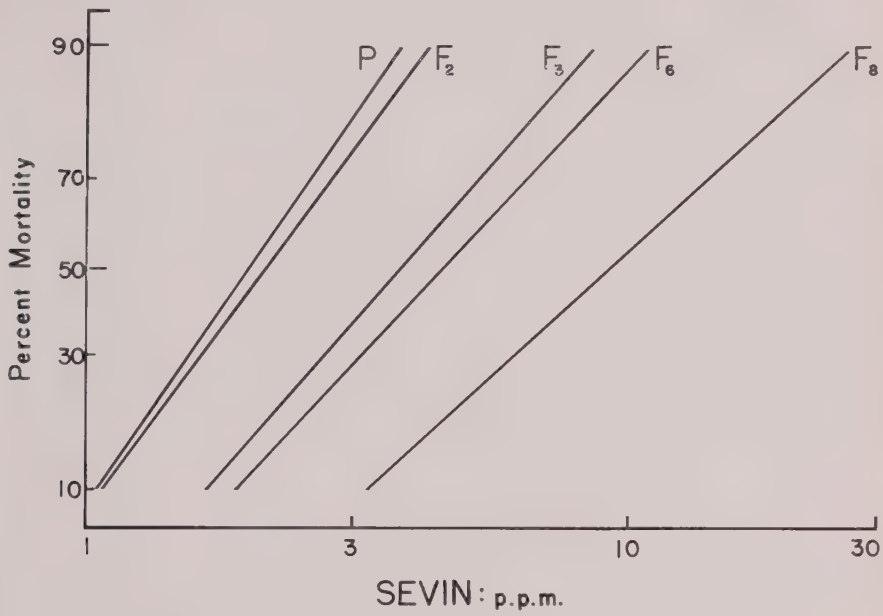

Fig. 2.—Dosage-mortality lines for Sevin shown by successive generations.

resistance to DDT (Fig. 4). These start with the abrupt steepening of the lower section in the F_1 generation. This is followed in the F_2 by a marked flattening of the upper part of the line, indicating the appearance of much more resistant types; another test on the same F_2 showed that all larvae in the sample had moved over to the resistant type with tolerances approaching 1 p.p.m. Subsequent pressure then moves the resistances beyond 1 p.p.m. by a marked flattening of the line again. A similar very flat line for the F_8 generation, indicating in effect that 50 percent or more of the sample is completely resistant, is also encountered with DDD.

Adults of the F_8 generation were tested for their resistance to DDT by the standard WHO test method. The mortality at the highest concentration (4 percent DDT) was only 16 percent. The normal strain before selection by malathion pressure had shown an LC_{50} of 1.5 percent DDT, and 16 percent mortality at 0.7 percent DDT. It may therefore be concluded that the DDT-resistance level of the adults of this malathion-selected strain had increased to approximately 6 times the normal. On the other hand, the adult LC_{50} to malathion had only increased from 1.8 to 2.2 percent.

Discussion. This malathion-resistance induced in larvae of the Penang strain of *Aedes aegypti* is specific in that it does not extend to parathion and diazinon. Therein it resembles malathion-resistance in house flies, which Busvine (1959) and others have found to be separate from parathion- and diazinon-resistance. Malathion-resistance in *Culex tarsalis* also did not extend to parathion or other OP compounds (Gjullin & Isaak, 1957), and parathion-resistance in *Aedes nigromaculis* did not extend to malathion (Lewallen & Nicholson, 1959). The malathion-resistance in our *A. aegypti* is not specific in that it extends to Sevin; but therein it resembles the situation in house flies, in

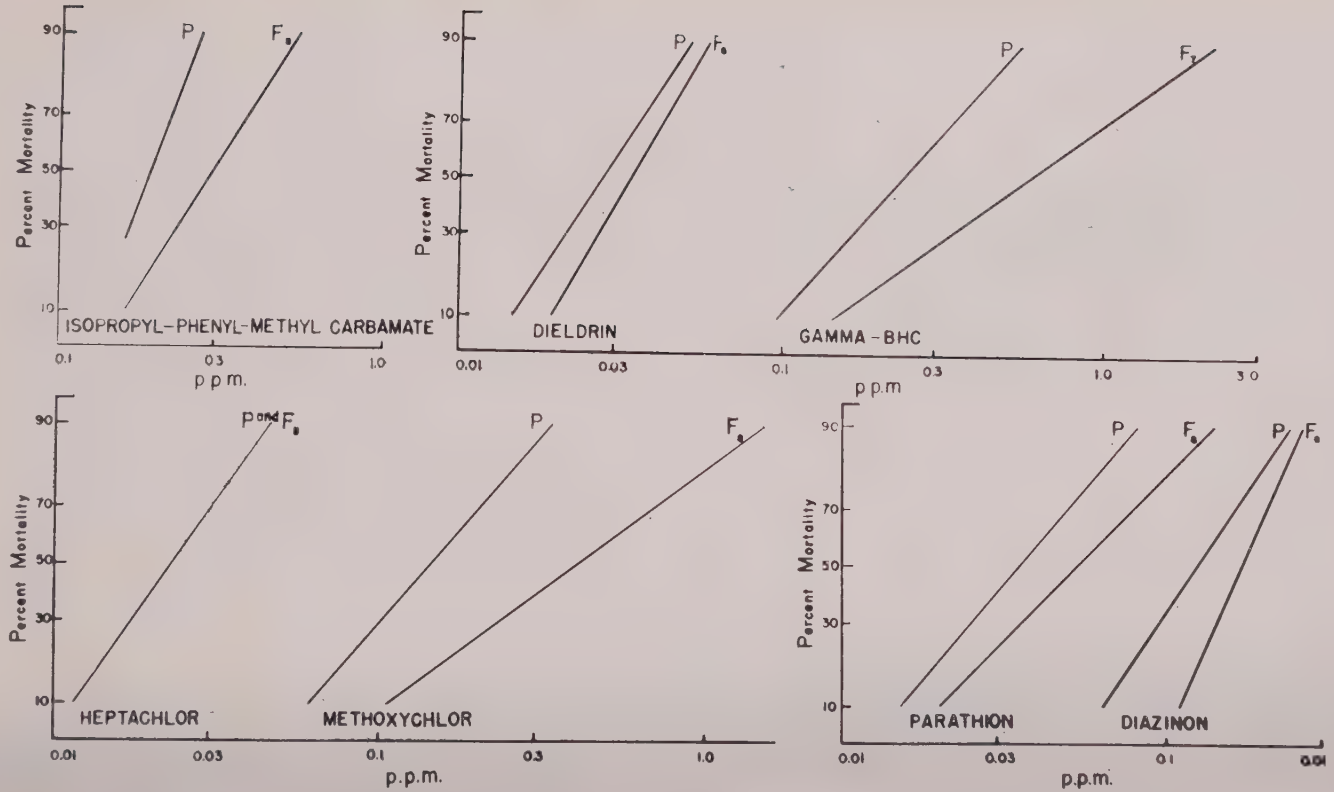

FIG. 3.—Dosage-mortality lines for gamma-BHC, dieldrin, heptachlor, parathion, diazinon and a carbamate shown by successive generations.

which parathion-resistant (Eldefrawi, Miskus & Hoskins, 1959), malathion-resistant (LaBrecque, Wilson & Smith, 1959) and diazinon-resistant (Forgash & Hansens, 1959) strains have been found to show cross-tolerance to Sevin.

The malathion-tolerance in *A. aegypti* also resembles that in house flies by involving a tremendous cross-resistance to DDT. This curiosity has been observed in many laboratory strains of house flies never exposed to DDT (Brown, 1958), which were also found to have developed the detoxifying enzyme DDT-dehydrochlorinase. In the Penang strain the ability to produce DDE was already well-developed before selection pressure was applied, and in the development of DDT-resistance by malathion pressure on this strain there was only a 40 percent increase in DDE production, about the same as developed under DDT pressure (Chattoraj & Brown, 1960). That this cross-resistance to DDT and DDD did not extend to methoxychlor is an argument against concluding that DDT-dehydrochlorinase is a mechanism for it. The malathion-resistance discovered in the Fresno strain of *Culex tarsalis,* on the other hand, was associated with no change from the normal in susceptibility to DDT (Gjullin & Isaak, 1957).

SUMMARY. Larvae of a strain of *Aedes aegypti* from Malaya, selected with mala-

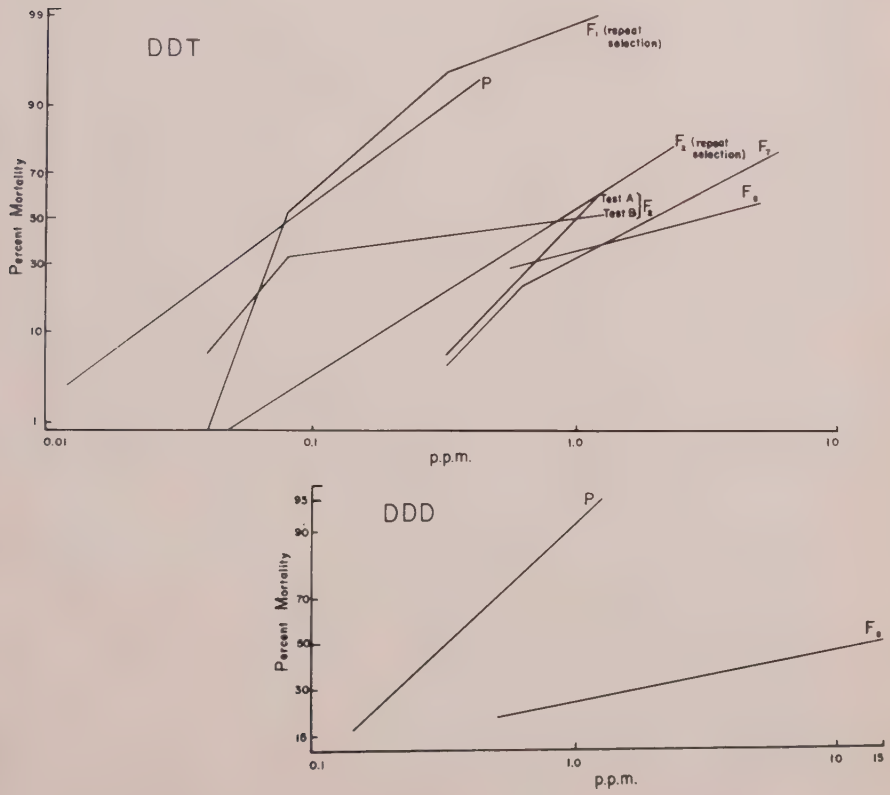

FIG. 4.—Dosage-mortality lines for DDT and DDD shown by successive generations.

thion for 8 generations, increased in malathion-tolerance by 5 times. They increased only slightly in their tolerance of parathion or diazinon. Their cross-resistance also increased by 5 times to Sevin but not to another carbamate insecticide. The tolerance of dieldrin, heptachlor and gamma-BHC increased slightly or not at all. They developed a cross-resistance in excess of 30 times the normal to DDT and DDD, but not to methoxychlor. Although the selection pressure was confined to the larvae, the adults also developed a 6-fold resistance to DDT.

This work was performed on a grant-in-aid from the National Institutes of Health.

References

ABEDI, Z. H. and BROWN, A. W. A. 1960. Development and reversion of DDT-resistance in *Aedes aegypti*. Can. J. Genet. Cytol. 2: in press.

BROWN, A. W. A. 1958. The World Health Organization test kit for detection of resistance in mosquito larvae. Mosquito News 18:128–131.

BUSVINE, J. R. 1959. Patterns of insecticide resistance to organophosphorus compounds in strains of houseflies from various sources. Ent. Exp. Applic. 2:58–67.

CHATTORAJ, A. N. and BROWN, A. W. A. 1960. Internal DDE production by normal and DDT-resistant larvae of *Aedes aegypti*. J. Econ. Ent. 53: in press.

ELDEFRAWI, M. E., MISKUS, R. and HOSKINS, W. M. 1959. Resistance to Sevin by DDT and parathion-resistant houseflies. Science 129:898–899.

FAY, R. W. 1956. Insecticide resistance in *Aedes aegypti*. Amer. J. Trop. Med. Hyg. 5:378.

FORGASH, A. J. and HANSENS, E. J. 1959. Cross resistance in a diazinon-resistant strain of *Musca domestica* (L). J. Econ. Ent. 52:733–739.

GJULLIN, C. M. and ISAAK, L. W. 1957. Present status of mosquito resistance to insecticides in the San Joaquin Valley in California. Mosquito News 17:67–70.

KELLER, J. C. and CHAPMAN, H. C. 1953. Tests of selected insecticides against resistant salt-marsh mosquito larvae. J. Econ. Ent. 46:1004–6.

LABRECQUE, G. C., WILSON, H. G. and SMITH, C. N. 1959. Effectiveness of two carbamates against DDT- and malathion-resistant house flies. Jour. Econ. Ent. 52:178–9.

LEWALLEN, L. L. and BRAWLEY, J. H. 1958. Parathion resistant *Aedes nigromaculis*. California Vector Views 5(8):56.

LEWALLEN, L. L. and NICHOLSON, L. M. 1959. Parathion-resistant *Aedes nigromaculis* in California. Mosquito News 19:12–14.

CALIFORNIA MOSQUITO CONTROL ASSOCIATION, INC.

1737 West Houston Avenue, Visalia, California

1961 JOINT MEETING

American Mosquito Control Association, 17th Annual Meeting

California Mosquito Control Association, 29th Annual Meeting

Tuesday—Wednesday—Thursday

January 31st, February 1st and 2nd, 1961

Headquarters: Disneyland Hotel, Anaheim, California

Information available from:

CMCA President: Gardner C. McFarland, Manager
Southeast M. A. D., South Gate, Calif.

CMCA Secr.-Treas.: Wm. Donald Murray, Manager
Delta M. A. D., Visalia, Calif.

CMCA Program Chairman: John H. Brawley, Manager
Kings M. A. D., Hanford, Calif.

CMCA Local Arrangements: Jack H. Kimball, Manager
Orange County M. A. D. Santa Ana, Calif.

Wives and children invited

MORE ABOUT *CULEX*

FRANKLIN C. WRAY
Technical Director, Desplaines Valley MAD, Lyons, Ill.

At last year's meeting in Salt Lake City I reported on our district's problems with *Culex pipiens* breeding in the sludge lagoons of the Metropolitan Sanitary District of Greater Chicago. This paper discusses another phase of the *Culex* control problem in our area.

Although the sludge lagoons are by far the largest single breeding place of this species in our District, they are not the only one; our Annual Report lists 111 known *Culex* breeding places—mostly small ditches polluted by septic systems, dumps, and the like.

Culex pipiens have increased in numbers and degree of annoyance during recent years as evidenced by trap catches, field inspectors' observations and complaints of the public.

This year's trap catch of female *Culex pipiens* was the second highest in the last six years, exceeded only by the mosquito population after the flood of July 12, 1957. Traps recorded four or five times as many *Culex pipiens* in June as in previous years.

The increase was a general infestation that could not be attributed to any one source or restricted to any special areas. *Culex pipiens* breeding in the sludge lagoons of the Metropolitan Sanitary District of Greater Chicago was at least 50 percent less than in 1958. These lagoons did not reach normal breeding until the first of July, several weeks after increase in this species elsewhere in the district.

Ninety-five percent of the *Culex* breeding places are in Lyons township—location of numerous new subdivisions. Many of these breeding places are in the immediate vicinity of the adjoining villages of Willow Springs, Western Springs and LaGrange Highlands in the southwest section of the district, sources of most complaints in late August of 1959.

As rural areas are rapidly transformed into suburban residential areas by mushrooming subdivisions, marshes and open field floodwater areas are eliminated with an attendant decline of floodwater mosquito populations. The newly created suburbs, usually unincorporated, create numerous small polluted areas with a resultant increase in populations of *Culex pipiens* and other mosquitoes of polluted water.

Those in Willow Springs will be eliminated by a recently installed sewer. Likewise, construction of a sewer will begin this spring in the LaGrange Highlands area, resulting in a total removal of 25 small polluted breeding areas. The District is now endeavoring to secure cooperation of other local village and township authorities to eliminate the remainder.

Culex breeding began in early June with traps recording three times the average for the past six years, diminished slightly in July and increased again to twice normal in August and September. Every month of the breeding season except July had above normal temperatures.

Rainfall was 4 inches above normal in May, June and July, and then the weather became unseasonably dry during August and September, with a deficiency of 2.6 inches.

This combination of high temperatures and lack of rain is considered a prerequisite to prolific breeding of *Culex pipiens*. Such a condition did occur in 1959, preceded by two months of unseasonable *Culex pipiens* breeding severe enough to require additional larviciding.

The District had been aware of this unusual breeding situation through routine and special field inspections, trap catches and complaints from the public. Few *Aedes vexans* larvae had been noted after June 4, while collections of *Culex*

had been consistently heavy, averaging 15 to 20 per dip with a high of 120 at one location.

The day of reckoning came on August 14 when we were swamped with complaints from communities in the southwestern part of the district. Annoyance by *Culex pipiens* had become so severe that all seven fogging units were diverted to this area, covering it completely in one night.

Known polluted breeding places were inspected, found breeding heavily and immediately sprayed the following day with the usual DDT emulsion. Breeding continued unabated in spite of this spraying. After inspection the following day (August 16) they were resprayed with 8 percent DDT in No. 2 fuel oil, resulting in a 90 percent kill. *Culex pipiens* ceased to be an annoyance in these communities after this initial larviciding with 8 percent DDT in oil.

The scene of annoyance shifted on August 18 to that part of Riverside immediately adjacent to the Desplaines River, a distance of approximately one-half mile.

Literally hundreds of *Culex pipiens* invaded homes along the river bank, but decreased rapidly in number with increasing distances from the river.

At first it was thought mosquitoes had escaped from this area due to faulty inspection. However, further investigation indicated that the dense growths of water plants along banks had prevented good penetration of larvicide from mist blower in boat.

The river for a distance of 1½ miles adjacent to Riverside was sprayed twice with the boat and a hand crew, using standard DDT emulsion.

The by-pass at Hofmann Dam had been opened on August 28 just before the second spraying. The river level dropped 15 inches in 20 hours so that the water had all been pulled out of the weeds along the banks. In spite of this, the kill, using DDT emulsion, had still been less than 50 percent and annoyance continued at a high level throughout the Riverside area.

The only recourse was to spray the river with 8 percent DDT in fuel oil. This was done on September 3 and 4 with both the boat and the hand crew, having previously lowered the river level 18 inches by opening the by-pass a second time. The results were spectacular with a better than 85 percent kill where less than 50 percent had been killed by use of DDT emulsion.

This is a further confirmation of last year's observation that insecticide with fuel oil appeared to obtain a better and longer lasting effect against *Culex pipiens* in our district than use of emulsions or granular preparations.

ILLINOIS MOSQUITO CONTROL ASSOCIATION

EXECUTIVE COMMITTEE

President	*Past President*	*Member*
DR. G. F. OTTO Lake Bluff Mosquito Abatement District Lake Bluff, Illinois	Wilbur Mitchell Northwest Mosquito Abatement District Wheeling, Illinois	Francis P. Creadon DesPlaines Valley Mosquito Abatement District Lyons, Illinois
Vice-President	*Member*	*Secretary-Treasurer*
Leo Michl Decatur City Health Dept. County Building Decatur, Illinois	Brice E. Johns South Cook County Mosquito Abatement Dist. Harvey, Illinois	Harvey J. Dominick Illinois Dept. of Public Health Division of Sanitary Engineering Springfield, Illinois

MICROBIOLOGY AND MOSQUITO CONTROL [1]

MARSHALL LAIRD [2]
McGill University

Many, varied and most inadequately understood are the relations between mosquitoes and micro-organisms, a term used here in its broadest sense to cover all organisms that cannot be studied without the aid of a compound microscope. At the threshold of life even this instrument is of limited use, but, although numerous viruses are transmitted to man by mosquitoes, we are as yet unaware of any virus harmful to mosquitoes and thus of potential value as a biological control agent. This is not to say that such a viral pathogen does not exist, for atypical polyhedral inclusions occur in other Nematocera including the Tendipedidae (Weiser, 1948) and Tipulidae (Rennie, 1923). Noninclusion virus disease has been recorded from the latter family (Xeros, 1954), and *Calliphora vomitoria* suffers from polyhedrosis (Bergold, 1943).

There are several records of rickettsiae from mosquitoes, perhaps the best known species being *Wolbachia pipientis,* an apparently harmless parasite of the ovaries and testes of *Culex pipiens* (Hertig, 1936). It would be premature to draw any conclusions about either group from the existing literature, which is, however, more informative as regards relations between mosquitoes and bacteria, algae, fungi, protozoa and higher forms.

It is not intended to survey this literature, a task that in any case is now being completed by Dr. Dale W. Jenkins at Fort Detrick, Maryland. Instead, it is proposed to touch upon several types of relationship ranging from those between free-living aquatic micro-organisms and culicid eggs and larvae, to purely parasitic ones, with the object of highlighting some fruitful areas for ecological research of direct benefit to mosquito control.

Today, we are faced with control failures due to resistance and the non-selectivity of modern insecticides. At a time when biological remedies for these problems are being considered (Laird, 1959d; AIBS conference, 1960), it is important to realize that such remedies are by no means confined to the fields of parasitism and macro-predation.

We still know remarkably little of the factors influencing the choice of oviposition sites by mosquitoes, or of the relationship between these factors and the total ecology of the larval habitat. Mosquito workers investigating a particular locality soon learn to associate the major types of larval habitats with the species most likely to be found there. They are hard put to it, though, to explain this evidence of preference in their writings. Much of their difficulty is due to a narrowness of outlook and perhaps of basic training as well. Although they may attempt to define a larval habitat in terms of its more easily measured chemical and physical qualities, they too often overlook the fact that it is the home of a wide range of organisms other than mosquitoes. It is seldom that the field collector pays attention to these beyond making general notes on plant cover and the presence of particularly prevalent fish or large invertebrates. Should a gleaming dytiscid swim into his dipper, he may perhaps pop it into his jar along with the larvae, note subsequently that it has destroyed some of them, and proceed to carry out simple feeding experiments in which an otherwise starved beetle is provided with mosquito victims that it quite understandably (favoured as it usually is by the

[1] Contribution from the Institute of Parasitology, McGill University, Macdonald College P.O., Que., Canada, with financial assistance from the National Research Council of Canada.

[2] Associate Professor, McGill University. Member of the Expert Advisory Panel on Insecticides, World Health Organization.

congested quarters provided) captures and devours. A good deal of the literature on predation concerns work of this sort, which, of course, has its place in basic research. Few indeed, though, are quantitative studies of micro-limnology, or even qualitative reports including the listing of accurately identified animals and plants associated with developing mosquitoes. Better knowledge of these associations can lead to the development of much more precise criteria for the designation of larval habitats.

Again, a note on parasitism often has its origin in the finding of sickly larvae bearing a thick and obvious vestiture of bacteria, algae, fungi or protozoa, or combinations of these. Close host specificity is inferred without the more sweeping investigation that would have both disclosed the epibionts on other, frequently smaller and less conspicuous inhabitants of the water body concerned, and revealed the development of polysaprobic conditions. The latter at one and the same time render the habitat less and less tolerable to most mosquito larvae, and burden the debilitated survivors with passengers that flourish on many kinds of substrates in the presence of pollution (Laird, 1959b). Such organisms are in fact biological indicators of pollution, and well known as such to those concerned with sanitary aspects of water management. Although they are not parasites in the strict sense of the term at all, their presence may contribute towards the death of undernourished, infested animals.

The first points to be emphasized, then, are the danger of drawing erroneous conclusions from inadequate data, and the need for a keener sense of the importance of those concerned with mosquito control having a thorough grounding in freshwater biology.

Bacterial associates of mosquito larvae include *Siderocapsa Treubii,* the bacilloid cells of which occur in mucoid masses surrounded by iron deposits. This microorganism was first described from underwater leaves in Indonesia and later reported from slides suspended in alkaline waters in the U.S.A. (Hardman and Henrici, 1939). It was first reported as a mosquito larval epibiont at Singapore, where it occurred on culicines and an anopheline, as well as on *Pistia* leaves and in surface scum (Laird, 1959b). The late Dr. Willis E. Snow (p.c., 1958), whose tragic death last year deprived the U.S.A. of the services of an able ecologist, found the same or a closely related organism in Alabama floodwater pools and on larval *Psorophora ciliata* and *P. howardii* developing there. Associated culicines gave rise to dwarfed adults, apparently through the crowding out of suitable larval food organisms by the iron bacteria, which rapidly became extremely abundant. However, normal-sized adults duly developed from the infested *Psorophora,* these predators capturing tiny immature amphibians as culicines became scarce.

A declining oxygen gradient resulting from burgeoning bacterial activity in freshly filled pools, triggers the hatching of the eggs of floodwater mosquitoes (Gjullin *et al.,* 1941; Laird, 1956; Horsfall, 1956). As larvae emerge they find a ready source of nourishment in some at least of the thriving bacteria which, as Dr. Snow indicated, are soon so numerous that there is no longer a hatching stimulus, any eggs remaining unhatched thus providing "some carryover for another generation if the initial brood does not survive." Surely the great importance of floodwater and snow-melt mosquitoes on this continent, makes the identification of the various bacteria concerned, and field studies of their bionomics, highly desirable?

Streptococcus margaritaceus, often common in polluted waters, may adhere to the body surfaces of larvae occurring there. More evident epibionts under such conditions, though, are *Sphaerotilus dichotomus* and the well-known sewage bacteria, *Sphaerotilus natans* and *Zoogloea ramigera.* Appearing as greyish-white "beards" to the unaided eye, these organisms, when noticed on mosquito larvae, will also be found if searched for on other insects, notably Tendipedidae and

Anisoptera, as well as on dead vegetation and submerged objects (Laird, 1959b). Such bacteria on larval *Culex pipiens fatigans* in Shanghai, were viewed as parasites by von Jettmar (1947), who asserted that his "streptobacilli" penetrated the cuticle of the host and destroyed the epithelial cells concerned with chitin production. Studies on *Anopheles maculipennis atroparvus* laboratory colonies in Italy (Laird, 1958) have since established that heavy growths of *Sphaerotilus* and another biological indicator of pollution, *Vorticella microstoma,* may so hamper infested insects that these, already greatly weakened by undernourishment due to the deterioration of their food supply with the development of polysaprobic conditions, die from exhaustion as pupation or hatching demand energy expenditure of which they have become incapable.

Such weakened larvae fall ready victims to invasion by aquatic fungi, a useful account of which has recently been published by Emerson (1958). Their strength may be inadequate for the shedding of the old larval skin at ecdysis, and further growth of the insects, trapped in prisons of their own making, leads to the appearance of the hoops and circlets described by Langeron (1928) and correctly interpreted by Gaud (p.c., 1953) as hairs of the new envelope viewed through the persisting former one. More bizarre effects are the development of twisted antennae and double sets of clypeal spines, and of bent siphons. Certain normally free-living protozoons invade wounded or moribund larvae, and sometimes even healthy ones. Ciliates of the genus *Tetrahymena* are prominent in this respect (Lamborn, 1921; Corliss, p.c. 1959). Of course, care must be exercised to distinguish between such instances of facultative parasitism and post-mortem invasion by simple scavengers, like the flagellates, *Trachelomonas hispida* and *Peranema trichophorum*.

Under mesosaprobic conditions, the pollution state characterizing most of the zone of oxidation, algal epibionts may be evident. These include species of *Characium,* flourishing on Cladocera and spreading to mosquito larvae and associated animals. Snow-melt pools are often mesosaprobic, due to the spring-time decay of organisms killed there at the freeze-up at the beginning of the preceding winter. Entomologists working in subarctic America (Jenkins, 1948; Jenkins and Knight, 1950, 1952) have noted the occurrence of green algae on the anal papillae of mosquito larvae. Similar observations were made during a visit to Ungava Bay, northern Quebec, in the early spring of 1959, and an algal epibiont then collected from the copepod, *Acanthocyclops vernalis,* and Tendipedidae (*Anatopynia alaskensis*), as well as from mosquito larvae (*Aëdes* spp. and *Mochlonyx* sp.), has been identified as *Chlorangium stentorium* (original data).

Mesosaprobic waters often yield Cladocera bearing rotiferan epibionts, notably *Brachionus rubens* (Laird, 1956, 1959b). They, too, spread to larval mosquitoes, which may even form temporary anchorages for small Cladocera browsing among bacterial, algal and ciliate epibionts.

Ciliates, sessile Peritricha, are in fact the most immediately obvious epibionts indicative of the different levels of pollution. Epistylids and many vorticellids are mesosaprobes. Dichotomously branching colonies of up to 46 individual zooids of *Epistylis lacustris* grow upon a diversity of aquatic animals, including microcrustaceans and mosquito larvae. *Vorticella campanula* and *V. convallaria* have been recorded from *Lutzia* larvae under similar mesosaprobic conditions.

The commonest of all mosquito ciliates is undoubtedly *Vorticella microstoma,* a genuine sewage organism found throughout not only the mesosaprobic zone but the polysaprobic one as well—the latter being the zone of massive pollution and decomposition, in which reduction of the polluting substances proceeds vigorously. Heavily infested larvae appear to the naked eye as if clothed with a whitish fur, and often bear *Sphaerotilus* too.

Although the epibionts that have been mentioned show no special preference for

mosquito larvae over other available substrates, and as has been indicated merely reflect environmental conditions, this is not to say that they may not be harmful on occasion. Larvae developing in mesosaprobic waters, although weighed down by masses of Peritricha, may still pupate and give rise to healthy adults (Laird, 1956). Should a polysaprobic situation develop, though, as in the case of intermittently manured water hyacinth ponds in the Oriental Region, the advent of unfavourable chemical and physical conditions, coinciding with the supplanting of preferred food organisms by bacteria and saprozoic protozoa including facultative parasites, combine to prejudice survival of the mosquitoes. Already undernourished larvae, hampered by increasingly heavy growths of polysaprobic epibionts, are hard put to it to hold their own in the competition for such suitable nourishment as remains. Successive moults leave them feebler, more weakly chitinized, and less fitted for survival (Laird, 1959b).

I have dwelt at length upon these aspects of microbiology, because in them lies the key to a more selective approach to some, at least, of our mosquito control problems. Knowledge of larval habitat ecology has made little progress since the localized naturalistic control efforts of the years between the World Wars—when Rice and Savage (1932) used cattle manure for weekly treatment of borrow pits in Assam and thereby completely prevented the breeding of *Anopheles minimus,* and Ramsay and Savage (1932) in India, Hargreaves (1933) in Uganda and Martial (1937) in Indo-China, to name only some of those concerned, achieved similar results with pollution of ponds by rotting vegetation. Williamson (1936, 1949) should be referred to for a full discussion of these matters which, in the face of the threatening resistance impasse, fully warrant critical reappraisal.

This account must not conclude without brief reference to some of the *bona fide* parasites of mosquitoes. An example of a long established parasite, completely adjusted to its host which does not *appear* to suffer harm from its presence, is the gregarine protozoon *Lankesteria culicis.* This organism has been found wherever searched for in *Stegomyia* populations and in certain other mosquitoes too. Its trophozoites occur in the larval gut, first within epithelial cells and then free in the lumen. At pupation the gregarines, now mature gametocytes, enter the Malpighian tubules and associate in pairs to form spherical gametocysts. Their individuality is soon lost, repeated nuclear divisions take place and myriads of spores are finally formed. These are released upon rupture of the sporocysts in the Malpighian tubules or hind gut of the adult. Accounts of this well-known organism include those of Ray (1933) and Ganapati and Tate (1949). Emphasis was earlier placed on the fact that the host does not *appear* harmed. This is a reflection of the lack of appreciation of the importance of such parasites as population-regulating factors, a function not necessarily bound up with a high level of pathogenicity. It is questionable whether the Malpighian tubules can suffer massive damage without at least some harm being caused thereby, and as *Aedes aegypti,* one of the natural hosts for *Lankesteria culicis* is being increasingly used as a laboratory test animal, it would be wise to ensure from the outset that colonies established for resistance testing and other purposes are gregarine-free.

More spectacular in their effects are some of the microsporidian parasites. Garnham (1956) and Canning (1957) have described the infection of a laboratory colony of *Anopheles gambiae* with *Plistophora culicis,* from 50 to 100 percent of the adults being parasitized. However, the microsporidians were chiefly confined to the Malpighian tubules, and serious harm did not seem to result. *Plistophora collessi* described from two Singapore culicines, is of rather more significance. This species causes a most effective sterilization. At the same time, the females, denied the possibility of laying eggs, seem able to lay spherical cysts each of which contains an average of four million spores. In view of so effective a means of seeding fresh larval

habitats, it may seem surprising that the incidence of *Plistophora collessi* in nature is only of the order of 1 percent (Laird, 1959a). The explanation presumably lies in the fact that biological equilibrium between the parasite and its hosts was attained long ago, but once again, studies on the population-regulating significance of the association are highly desirable—this time, with a view to the possible value of the organism as a biological control agent for use in areas where susceptible vectors or pest mosquitoes are as yet free from infection.

Mermithid nematodes have been viewed by a number of authors (e.g. Welch, 1958) as promising material for biological control research. Jenkins and West (1954) reported infections of up to 100 percent of larvae in subarctic pools—although neighbouring pools were sometimes quite free from the parasites. Why this should be so we know no more of than the reasons underlying the erratic distribution and incidence of what are at present the most promising of all mosquito pathogens for biological control research, the fungal parasites of the genus *Coelomomyces* (Couch, 1945; Couch and Dodge, 1947; Laird, 1959c). The host usually dies without pupating, through destruction of the fat body and imaginal buds (Keilin, 1921; Iyengar, 1935), its body packed with sporangia. These may be plain or variously sculptured, and their presence in quantity makes infected larvae stand out from normal ones by a general rusty colouration and the chalky or tawny appearance of the anal papillae. After suitable conditioning the resting sporangia finally rupture, releasing flagellate zoospores.

An attempt to establish *Coelomomyces stegomyiae* in a previously uninfected mosquito population is currently proceeding in an isolated group of South Pacific atolls, the Tokelau Islands, under the sponsorship of the World Health Organization and with New Zealand government co-operation. Infective material derived from parasitized *Aedes albopictus* at Singapore was introduced into 761 larval habitats of *Aedes polynesiensis,* the primary vector of the filariasis parasite *Wuchereria bancrofti,* in the central and eastern South Pacific, in September, 1958. A return visit for assessment purposes is planned for April, 1960.

It is hoped that this pilot project will help pave the way for further introductions of mosquito pathogens, and specific predators too, from areas where they are endemic and in balance with host or prey populations to others in which they are not. It cannot be too strongly emphasized, though, that little of general value can be expected from such experiments until a great deal more has been learned concerning the distribution, host-parasite relationships and life histories of these mosquito enemies. Detailed and integrated studies on a global basis are called for if this approach to mosquito control is to become, as it must become, more than a blundering meddling with natural economy. Allied ecological research can lead towards a less direct form of biological control, too. By taking advantage of associations and cycles of freshwater organisms that are already worldwide, is it not possible to add specific environmental management techniques to the mosquito control armory? Both fields demand a global conception, an attitude of mind that is fortunately becoming rapidly more accepted in scientific fields today, thanks largely to modern advances in transportation and an increasing abundance of research funds. An interesting illustration of this was lately given by Friedmann (1960), who, in a detailed examination of the subject, commented that one of the advisers to a University of Michigan group contemplating establishing a field station for tropical zoology, suggested that they do so in the interior highlands of New Guinea rather than in relatively nearby Mexico!

New and exciting horizons for mosquito control will open up once field stations already in existence begin to devote attention, equal to that already accorded chemical insecticide research, to parasitology and ecology, under the guidance of a

central planning group set up to prevent needless duplication of endeavor, arrange for rapid identifications, and integrate and make practical use of the data collected.

Literature Cited

AIBS. 1960. Conference on the biological control of insects of medical importance. Washington, D.C., February 3–4, 1960. Arranged by the American Institute of Biological Sciences (Proceedings to be published).

BERGOLD, G. 1943. Über Polyederkrankheiten bei Insekten. Biol. Zentbl. 63:1–55.

CANNING, E. U. 1957. On the occurrence of *Plistophora culicis* Weiser in *Anopheles gambiae*. Riv. Malariol. 36:39–50.

CORLISS, J. O. 1959. Personal communication, with typescript of a manuscript, now in press, on facultative parasitism in *Tetrahymena*.

COUCH, J. N. 1945. Revision of the genus *Coelomomyces*, parasitic in insect larvae. J. Elisha Mitchell Sci. Soc. 61:124–136.

COUCH, J. N. and DODGE, H. R. 1947. Further observations on *Coelomomyces*, parasitic on mosquito larvae. J. Elisha Mitchell Sci. Soc. 63:69–79.

EMERSON, R. 1958. Mycological organization. Mycologia 50:589–621.

FRIEDMANN, H. 1960. Changing environment of zoological research. Science 131:590–593.

GANAPATI, P. N. and TATE, P. 1949. On the gregarine *Lankesteria culicis* (Ross), 1898, from the mosquito *Aëdes (Finlaya) geniculatus* (Olivier). Parasitology 39:291–294.

GARNHAM, P. C. C. 1956. Microsporidia in laboratory colonies of *Anopheles*. Bull Wld Hlth Org. 15:845–847.

GAUD, J. 1953. Personal communication.

GJULLIN, C. M., HEGARTY, C. P. and BOLLEN, W. B. 1941. The necessity of a low oxygen concentration for the hatching of *Aëdes* mosquito eggs. J. Cell. Comp. Physiol. 17:193–202.

HARDMAN, Y., and HENRICI, A. T. 1939. Studies of freshwater bacteria V. The distribution of *Siderocapsa treubii* in some lakes and streams. J. Bacteriol. 37:97–104.

HARGREAVES, H. 1933. Report of the Government Entomologist, 1932. Ann. Med. and San. Rept., Uganda:86–90.

HERTIG, M. 1936. The rickettsia, *Wolbachia pipientis* (gen. et sp. n.) and associated inclusions of the mosquito, *Culex pipiens*. Parasitology 28: 453–486.

HORSFALL, W. R. 1956. Eggs of floodwater mosquitoes III (Diptera, Culicidae). Conditioning and hatching of *Aëdes vexans*. Ann. Ent. Soc. Amer. 49:66–71.

IYENGAR, M. O. T. 1935. Two new fungi of the genus *Coelomomyces* parasitic in larvae of *Anopheles*. Parasitology 27:440–449.

JENKINS, D. W. 1948. Ecological observations on the mosquitoes of Central Alaska. Mosquito News 8:140–147.

JENKINS, D. W. and KNIGHT, K. L. 1950. Ecological survey of the mosquitoes of Great Whale River, Quebec. Proc. Ent. Soc. Wash. 52:209–223.

JENKINS, D. W. and KNIGHT, K. L. 1952. Ecological survey of the mosquitoes of southern James Bay. Amer. Midl. Nat. 47:456–468.

JENKINS, D. W. and WEST, A. S. 1954. Mermithid nematode parasites in mosquitoes. Mosquito News 14:138–143.

JETTMAR, H. M. VON. 1947. Mikrobien als Feinde von Stechmückenlarven. Acta Tropica 4: 193–208.

KEILIN, D. 1921. On a new type of fungus: *Coelomomyces stegomyiae* n.g., n.sp., parasitic in the body cavity of the larva of *Stegomyia scutellaris* Walker (Diptera, Nematocera, Culicidae). Parasitology 13:226–234.

LAIRD, M. 1956. Studies of mosquitoes and freshwater ecology in the South Pacific. Royal Society of New Zealand, Bulletin No. 6. 213 pp.

LAIRD, M. 1958. A secondary effect of DDT upon the aquatic microflora and microfauna. Can. J. Microbiol. 4:445–452.

LAIRD, M. 1959a. Malayan Protozoa I. *Plistophora collessi* n.sp., (Sporozoa: Microsporidia), an ovarian parasite of Singapore mosquitoes. J. Protozool. 6:37–45.

LAIRD, M. 1959b. Parasites of Singapore mosquitoes, with particular reference to the significance of larval epibionts as an index of habitat pollution. Ecology 40:206–221.

LAIRD, M. 1959c. Fungal parasites of mosquito larvae from the Oriental and Australian Regions, with a key to the genus *Coelomomyces* (Blastocladiales: Coelomomycetaceae). Can. J. Zool. 37: 781–791.

LAIRD, M. 1959d. Biological solutions to problems arising from the use of modern insecticides in the field of public health. Acta Tropica 16:331–355.

LAMBORN, W. A. 1921. A protozoon pathogenic to mosquito larvae. Parasitology 13:213–215.

LANGERON, M. 1928. Les larves anormales de moustiques, ou larves à collier et à cerceaux. Ann. Parasit. Hum. Comp. 6:273–283.

MARTIAL, J. E. 1937. Le paludisme à Lang Son. Ann. Méd. Pharm. Colon. 35:1132.

RAMSAY, G. C. and SAVAGE, J. DE LA M. 1932. The principles and methods of malaria control in Assam. Brit. Med. J. 2:790.

RAY, H. 1933. On the gregarine, *Lankesteria culicis* (Ross) in the mosquito, *Aëdes albopictus* Skuse. Parasitology 25:392–396.

RENNIE, J. 1923. Polyhedral disease in *Tipula paludosa* (Meigen). Proc. Roy. Physiol. Soc. 20: 265–267.

RICE, E. M. and SAVAGE, J. DE LA M. 1932. Malaria survey of two tea estates in Upper Assam. Rec. Mal. Surv. India 3:219.

SNOW, W. E. 1958. Personal communication.

WEISER, J. 1948. Zwei interessante Erkrankungen bei Insekten. Experientia 4:317.

WELCH, H. E. 1958. A review of recent work on nematodes associated with insects with regard to their utilization as biological control agents. Proc. 10th Int. Congr. Ent., 1956, 4:863–868.

WILLIAMSON, K. B. 1936. References and notes supplementary to "The control of rural malaria by natural methods." Ser. I–III, Publ. League of Nations Eastern Bureau, Singapore. 89 pp.

WILLIAMSON, K. B. 1949. Naturalistic measures of anopheline control. Chapter 62, pp. 1360–1384 in *Malariology,* ed. M. F. Boyd, Vol. II. Saunders, Philadelphia.

XEROS, N. 1954. A second virus disease of the leatherjacket, *Tipula paludosa.* Nature 174:562.

THE CONTROL OF MOSQUITOES BY PATHOGENIC MICROORGANISMS

WILLIAM R. KELLEN [1]

The control of mosquitoes by pathogenic microorganisms is just one segment of the biological control method of combating insect pests with parasitic microbes. Although the concept of microbial controls is not new, and living pathogens of insects have been tested in the field against a variety of agricultural pests in various parts of the world for many years with very promising results, the application of microbial control to vector species is only now being recognized. Most of the basic problems involved in the use of microorganisms for mosquito control work are common to the subject of microbial control in general; however, each kind of pathogen and host presents its own problems as well.

The basis for accepting microbial control as a method for mosquito abatement worthy of serious consideration lies in the knowledge that mosquitoes are attacked by many naturally occurring pathogens. Workers have frequently observed populations of mosquitoes which were decimated by diseases. Muspratt (1946) reported having sampled a larval population of *Anopheles gambiae* Giles in Africa with about 95 percent of the individuals infected with a fatal disease caused by a fungus (*Coelomomyces*). Kudo (1924) noted that protozoan parasites belonging to the order Microsporidia are commonly found in mosquitoes. He frequently found larval populations with infection rates of about 5 percent, while a population of *Anopheles crucians* Wiedemann was observed in Georgia with over 50 percent of the larvae infected. Similarly, Weiser (1956) observed populations of *Aedes* and *Anopheles* in Czechoslovakia with about 5 to 10 percent of the larvae infected with microsporidians.

Observations by the writer in California during the summer of 1959 indicate that microsporidian parasites of at least some species of mosquitoes are evidently extremely common. Larval populations of *Culex tarsalis* Coquillett, for example, were sampled over a six month period in a wide variety of habitats in the San Joaquin Valley and adjacent foot-hills of the Sierra Nevada Mountains, and infection rates ranging from about 5 to 20 percent were almost invariably found. Other species found infected included *Culex peus* Speiser, *C. apicalis* Adams, *Culiseta incidens* (Thomson), (Fig. 1), and *Anopheles franciscanus* McCracken. Infected larvae of these species usually succumb to the infections before pupation occurs, while less than 3 percent of the individuals observed in the laboratory survived to the adult stage. Presumably similar rates of infection occur in many species of mosquitoes throughout the United States. It is perhaps significant that despite the great interest in mosquitoes in California, there was only one prior record of diseased mos-

[1] Bureau of Vector Control, California State Department of Public Health.

FIG. 1.—Fourth instar larvae of *Culiseta incidens* (Thomson). The larva on the right is infected with a microsporidian parasite belonging to the genus *Thelohania*.

quitoes in the state (Steinhaus, 1951). This reflects our lack of information about mosquito diseases, which is due, in part, to the difficulty of recognizing infected larvae in the field. No doubt many mosquito populations succumb to natural diseases; to the casual observer, however, their disappearances are credited to unknown causes. Unquestionably, the majority of mosquito pathogens are still unknown, while practically nothing is understood about the factors which favor the establishment of diseases in the field or the means by which their abundance can be promoted.

In the past, workers in the field of microbial control have directed most of their attention toward the study and utilization of bacterial and fungal parasites; this, however, is not an indication that these two groups of pathogens are the most abundantly represented agents of insect diseases, but merely a reflection that the two groups have had the benefit of more thorough investigation by specialists. Bacteria and fungi have known characteristics which make them easily manipulated under laboratory conditions, and have the advantage of being relatively easy to cultivate on artificial media. Moreover, they are generally considered ideally suited for purposes of microbial control, as they usually develop resistant spores, which can be produced in large quantities in the laboratory and stored for future use in the field. The development of resistant spores is highly desirable, as they can be formulated into dusts and sprays which can be applied in the field with conventional equipment.

Protozoan parasites also have resistant stages, while viruses can be stored in the dry state like bacteria; however, these two types of pathogens, because of our incomplete knowledge of their growth requirements, have not yet been cultivated artificially. In order to develop large quantities of these organisms for field tests it has been necessary to rear them in living colonies of their natural hosts. Whether it will be possible to rear these agents away from living tissues in the near future is problematical; rearing them in living hosts, however, presents no serious difficulty if their use in microbial control demands it.

More important is the problem of the infectivity of the resistant stages of the various mosquito pathogens once they have been exposed to hosts in the field. Pathogens occurring naturally in a habitat usually infect only a relatively small percentage of the host population, even though it is evident that certain disease agents are abundantly available. Epizootics, however, have been observed to develop very suddenly, leading to the devastation of entire populations; this presumably indicates that some mosquito populations are uniformly susceptible to disease, but conditions which render the pathogens infective or make the hosts susceptible occur infrequently.

As far as is known, all mosquito pathogens applicable to microbial control are one-host parasites, and infections are typically initiated through the alimentary canal. Presumably all new infections originate from spores which have been deposited in the habitat from the bodies of hosts which have succumbed to the disease. Undoubtedly only a very small percentage of the spores available in a habitat are ingested by suitable host species, and probably only a fraction of these spores is infective.

The precise conditions favoring the transmission of diseases to new hosts are apparently available to only a small percentage of the pathogens produced in nature. The release of the pathogenic agent from the resting spore stage is a critical step in the history of an infection; the physicochemical conditions of the host's gut are no doubt very important and stimulate the pathogen to terminate the quiescent stage. The limited information at hand, however, indicates that spores, particularly those of fungi and protozoa, frequently require a stimulus or maturation period external to the host; this must take place before the spores can be activated to attack the host's tissues after being ingested.

Workers have investigated the infectivity of mosquito pathogens by exposing healthy colonies of larvae in the laboratory to spores of fungal and protozoan pathogens; results of such tests have almost always been negative. These failures emphasize the difficulties of working with pathogenic microorganisms and our lack of knowledge of how the agents are transmitted in the field. The writer has exposed healthy mosquito larvae to soil and water from areas in which larvae naturally infected with microsporidians had been collected. Infections in over 10 percent of the exposed larvae have been obtained in this way. Exposure of larvae to fresh spores, however, has given only negative results. Evidently, therefore, the spores obtained with soil from the field which initiated laboratory infections had been exposed to conditions which rendered them infective. Further tests were conducted by exposing larvae to such spores which had been dried and rehydrated; these have given variable results and indicate that perhaps the initial drying of the spore is at least one step in the process. It is evident that an understanding of the process would perhaps place us in a position to encourage epizootics.

The important question is, of course, whether or not it is reasonable to expect that microbial control will ever be developed as an economic method for combating mosquitoes, or will the pathogens prove only of academic interest? It is evident that mosquitoes are attacked by the same general kinds of pathogens as have been used successfully against agricultural pests, i.e., bacteria, fungi, and protozoa. Viruses which are pathogenic to mosquitoes have not been convincingly demonstrated, but it seems likely that they also occur. Since microbial control has been accepted as an economic control method in agriculture, there appears little doubt that it also has a future in the control of pests of public health importance.

References Cited

KUDO, R. 1924. Studies on Microsporidia parasitic in mosquitoes. III. On *Thelohania legeri* Hesse (= *illinoisensis* Kudo). Arch. Protistenkunde, 49:147–162.

MUSPRATT, J. 1946. On *Coelomomyces* fungi causing high mortality of *Anopheles gambiae* larvae in Rhodesia. Ann. Trop. Med. Parasitol., 40:10–17.

STEINHAUS, E. A. 1951. Report on diagnoses of diseased insects 1944–1950. Hilgardia, 20: 629–678.

WEISER, J. 1958. Protozoan diseases in insect control. Proc. Tenth Inter. Congr. Ent., 4: 681–685.

ARTICLES

BEHAVIOR PRECEDING MIGRATION IN THE SALT-MARSH MOSQUITO, *AEDES TAENIORHYNCHUS* (WIEDEMANN)

JAMES S. HAEGER [1]

The mechanics of the early stages of insect migration have been studied in but very few species. Two outstanding examples are the desert locust (*Schistocerca gregaria* Forskål) as summarized by Kennedy (1951) and the southern white butterfly (*Ascia monuste* Linnaeus) as described by Nielsen and Nielsen (1950). In these two migratory insects the behavior leading to the migratory exodus has been both described and related to the migration itself. Because of their large size the diurnal migrations were more easily observed. Corresponding studies of the migratory but small and nocturnal salt-marsh mosquito, *Aedes taeniorhynchus* (Wiedemann) have been under way in Florida since 1951, by the group at the Entomological Research Center of which I am a member. Previous to that year nothing advancing our knowledge of the mechanics of mosquito migration had appeared except the pioneering and monumental contribution of Smith (1904). The present paper is the second report on the premigration behavior, being a sequel to the paper by Nielsen (1958). Background information on the life history, behavior, and migrations of this mosquito may be culled from earlier works by staff members of the Entomological Research Center (Nielsen and Nielsen, 1953; Nielsen and Haeger, 1954, 1960; Provost, 1952, 1957; and Haeger, 1955, 1958).

Nielsen (1958) reported that new adults of both sexes leave the emergence site when 6 to 13 hours of age, provided it is in the dark period of the 24 hours, but we have found the minimum age at twilight exodus to be most often 6 to 8 hours. If large numbers were of that age or older a spontaneous mass departure would then take place at dusk. Nielsen assumed these departures initiated the migratory flight. The degree of hypopygial rotation was used as a measure of age in departing males. The departing females sampled had immature ovaries and empty spermathecae, proving they had not yet mated. Subsequent to these observations it was learned that mating did at times occur before the migratory exodus (Haeger, 1955; Nielsen and Haeger, 1960) as did also nectar feeding (Haeger, 1955). The present paper describes in detail the behavior observed preceding migratory exodi of this species in Florida, including some of the largest mass flights of mosquitoes ever reported.

Since one of the primary objectives of this paper is to report on sexual behavior prior to migration, it is important to know that males commonly attain hypopygial rotation of over 135° in from 12 to 18 hours and some as early as 10 hours (Nielsen, 1958). It is also well to remember that pupation reaches a daily peak at sunset while the pupal duration is a function of temperature alone (Nielsen and Haeger, 1954). Another pertinent fact is that mating normally occurs before the females start biting or the males swarming, both latter habits being usually exhibited by a brood of adults when three days or so of age (Nielsen and Haeger, 1953). And, finally, it is recalled that the migration of this mosquito may readily disperse a brood 25 or more miles (Provost, 1952, 1957).

[1] Contribution No. 90, Entomological Research Center, Florida State Board of Health, aided by grants E-1492 and E-1408, National Institutes of Health, U. S. Public Health Service.

Brood I. Fort Pierce

On September 12, 1952 in the course of a dispersal experiment with radioactive-marked mosquitoes, thousands of copulations were seen among the departing migrants at twilight. This was our first observation of mass mating during an exodus, giving us the first intimation of where and when the truly significant mating occurred for a brood of *A. taeniorhynchus*. The details of this observation are given by Nielsen and Haeger (1960, in press). We were now alerted to the fact that mating under natural conditions could be better understood after closer scrutiny of initial departures from the emergence sites.

Brood II. Sanibel Island

The second case of mass mating behavior was observed in the marsh under totally natural conditions. It occurred on the evening of May 21, 1953. The emergence site for this brood was on the north shore of Sanibel Island, facing San Carlos Bay and 1-3/4 miles west of the ferry landing. It consisted of a 2–3 acre black mangrove (*Avicennia nitida*) swamp known as the "Dead Forest." Many of the mangrove trees had died several years before, but young trees (4–10 feet tall) were now replacing the old, most of which had rotted and fallen to the ground. Patches of pickleweed (*Batis maritima*) were well established throughout the sun-lit spaces on the marsh floor. These *Batis* areas made excellent egg-laying sites for the adult female mosquitoes. Living trees completely surrounded the dead area, even along the beach road but only an occasional old tree survived in the stricken area.

The previous brood was produced in April by high tides and resulted in a large emergence at the Dead Forest area. A seeming diversion here is necessary to clarify existing conditions of this previous population and its behavior up to the emergence of the May brood. It was during evening swarming studies in April that the first nectar feeding adults were observed by Dr. M. W. Provost and the author. This was a very important discovery as will be seen later when the potential of this habit was realized. During the first week after an emergence, nectar feeding commonly occurs each day and is easily observed. After about 10 days there is usually a sharp decline in feeding, on the 12th day only rarely seen, and after 13 days practically no nectar feeding occurs even though nectar may be plentiful in the flowers of as many as six major honey plants, in leaf-nectaries of another, and aphid honeydew is available. Returning now to May 21, the day of the big emergence in the Dead Forest, we find this was 27 days after the April brood emerged; nectar feeding no longer occurred, male swarming was over, and very few adult females were seen in either biting or light trap catches. Many thousands of eggs had been laid in the *Batis* and under logs and leaves at the Dead Forest during the 2–3 weeks previous to the May 16 tide flooding. The present brood of larvae was estimated to consist of several million animals. The development of the larvae was carefully watched and by the afternoon of May 20 about 50 percent had pupated but none had emerged. The next morning, May 21, at $08^h30'$ an inspection of the breeding area revealed that a great number of males had emerged sometime during the night. The emergence continued through the morning and early afternoon to $15^h00'$ when only a few stragglers were still emerging. The greatest concentration of emergence was among *Batis* plants and pneumatophores (aerial roots) of the black mangrove, *Avicennia,* where most of the pupae had congregated into large raft-like masses. The young trees, *Batis* plants, and aerial roots were literally covered with resting adults (see Figs. 1, 2). All the *Avicennia* trees were in their full splendor with terminally clustered white blossoms. Hundreds upon hundreds of the new mosquitoes were feeding on the blossoms but only to the 3–4 foot adult resting levels. They would walk about on the foliage and flowers while searching for the exceptionally fragrant nectar. Two hundred and fifty adults were counted on the ven-

FIG. 1.—Adult *Aedes taeniorhynchus* emerging from a large raft of pupae. Black mangrove aerial roots in center of picture are covered by adults 1–2 hours of age. *Batis* stems and leaves can be seen on left half of picture.

FIG. 2.—A close-up view of *Aedes taeniorhynchus* emerging from a corner of a raft of pupae.

tral sides of 5 mangrove leaves (because this side was favored over the top surface); the sex ratio was 3 ♂ to 1 ♀; compared to a nectar feeding ratio of 2 ♂ to 1 ♀ out of 150 adults counted on flowers. (These last observations were made between 15h00′ and 16h00′.) At 16h00′ I left the area to prepare for the evenings observations. Sunset was to be at 19h06′.

a. First Exodus of Brood II. Upon returning it was found that the adults were rapidly ascending into the higher tree canopy. Flower feeding continued to increase among both sexes. At this time they were gracefully flying to the flowers instead of walking over every flower head. By 19h10′ the feeding took place up to a height of 18–24 feet. There was such a great number feeding that they actually pushed one another aside to obtain nectar from the small flowers, the corollas of which measure 5 mm at the widest point. At this time (19h10′) the sex ratio of nectar feeders was 2 ♂ to 5 ♀ (10:25). At 19h15′ great numbers were moving up to the very tops of the tallest trees, 24–30 feet high, nectar feeding was continued by many individuals up to the take-off time. A few mosquitoes were now (19h17′) leaving on the initial migration. The weather was calm and a beautiful sunset was present, brightest in the north-west quarter. At 19h20′, 14 minutes past sunset, large waves of adults started leaving the branches in front of me as well as higher up, all seemed to be flying toward the brightest part of the sunset—the mass migration was on. A similar exodus into the sunset had been observed on April 22; also under conditions of complete calm. Five minutes later, 19h25′, they left in larger waves as if by signals, probably according to age groups, depending on time of emergence (see Fig. 3). No mating was seen yet, and I was wondering if it would take place. The primary observation site was about 4 feet east of a bushy black mangrove. The observer faced west towards a lateral branch 8 feet above the marsh floor, where a patch of sunset lighted sky shone through the foliage. At 19h30′ (24 minutes past sunset) nectar-feeding was still going on right up to the time of exodus. Many specimens could be seen with clear abdomens full of nectar; males did not hold nearly the quantity that females could. Still larger waves were leaving at 19h31′. The first matings now occurred at 19h32′ (26 minutes past sunset). Air temperature was 27.5° C.; still calm with not a leaf stirring. Such great numbers were now leaving that distinct waves were less noticeable. Fifteen copulations (in 2 minutes) were seen to occur immediately after the mosquitoes flew off the branch and its flower heads. The peak copulation period was during the next seven minutes, 19h38′ to 19h45′ (32–39 minutes past sunset) when it was estimated that 75 percent of all females leaving this branch were caught by males by the time they had flown 3–12 inches upward. After copulation these participating specimens continued to fly up at an angle toward the light western sky until they were lost from sight above the forest canopy. During this 7-minute period 98 complete copulations were counted. Several times two or three males would try to mate with the same female. In such cases the ball of fighting mosquitoes was very spectacular, usually one male succeeding in copulation. It was now 19h50′ and the number of departing migrants was tapering off (44 minutes after sunset) with some mating still taking place practically to the end of the departure. This exodus lasted 33 minutes and matings were observed over an 18-minute period. One hour later, at 20h50′ there was still a great singing of mosquitoes (high-pitched) in the air among or above the tree canopy which sounded like a "milling-about" flight. If they were migrants they did not seem to be going anyplace. No male top swarms were seen. The number of both sexes feeding on flower nectar was greatly reduced; these animals apparently were too young to leave.

Since only an occasional nectar-filled adult had been collected in the light trap two miles east at Punta Ybel during the past two weeks it was decided to check the light trap collection carefully on this exodus night of May 21, 1953, for this

FIG. 3.—An exodus of *Aedes taeniorhynchus* in the Hob Horse Cove area. As the adults fly from the low *Batis* vegetation below picture angle, most individuals fly into the wind which is blowing from right to left. The dead branches (upper center) and twigs (at right) are *Avicennia nitida*.

point. Between 21h30′ the light trap caught about 100 ♀ *A. taeniorhynchus* and 1 ♀ *Aedes sollicitans* (Walker) containing nectar, but not a single male was collected either with or without nectar. The next run from 22h30′ to 23h00′ caught about 50 ♀ *A. taeniorhynchus* and 4 ♀ *A. sollicitans* and still no males. These females all seemed to be recently emerged as shown by their perfect and beautifully scaled appearance. On the night of May 22 there were a great many males in the light trap, a good number of these also contained nectar. Each night's collection from May 23 to May 31 was examined and found to contain many nectar-fed animals of both sexes. There was no known emergence closer than two miles west of this trap, that being the Dead Forest area. The fact that no males were collected on May 21 by 23h00′ but many on May 22 may be accounted for by three possibilities; (1) the main migration was west or northwest, (2) the males dropped out short of the lighthouse on Punta Ybel and continued on to that point the second night, (3) or the second night's migration went more towards the east (Provost, 1952, 1957, found in both of his experiments that males were seldom attracted to light traps beyond two miles from the emergence site). The interior sloughs on Sanibel Island were not breeding during May, 1953.

b. SECOND EXODUS OF BROOD II. On the second day of emergence (May 22) at the Dead Forest, there appeared to be about the same number of adults emerged by 15h00′ as the day before at this hour, but the sex ratio of males to females was 1:1 instead of 2 or 3:1 as observed the pre-

vious day. The same behavior of resting and feeding was observed. At 17h45' E. T. Nielsen and I watched the start of their ascent into the trees, this phenomenon occurred 45 minutes earlier than on the previous day due to clouds practically obliterating the sunset. Eight complete copulations were seen during the six-minute period between 24 and 30 minutes after sunset. It was now 19h36' and rain and poor light made further observations at the site (under the trees) impossible. There was loud humming above the tree tops so a nearby tree was climbed to facilitate observations since there were still a few light patches of sky above and east of the dark clouds. Between these two sites the tree canopy was open for about 20 feet. From my vantage point, standing on a limb 15 feet above the marsh, I could observe the great mosquito activity near the tree tops. Since my height is 6'4" the view at eye level was about 21 feet above the ground. I was practically among the singing, flying horde of mosquitoes. Above the tops of nearby dead trees very large top swarms were seen undulating back and forth like a cloud during the ascent of those which were leaving by the tens of thousands, supposedly on the migration. The closest swarms were 15 feet to the southwest and above my view at about a 30° angle (Dr. Nielsen was on the ground below as I gave him an account of the happenings at these levels). Copulations might have been taking place but the light intensity was too low to tell this. The interesting point was that swarms were formed on this second night when the oldest males were not much over 42 hours of age. This number of hours is given under the assumption that some of the adults observed the previous day at 08h30' were emerging during the night of May 20–21 (arbitrarily set at 24h00' on May 20). Later (October 16, 1958) it was found that evening swarms formed when the males were 22 hours of age.

BROOD III. HOB HORSE COVE

The third and largest brood ever observed during the initial stages of migration was in August 1955 and involved some 60,000,000 specimens, according to estimates made of pupal raft density and extent. This large brood was located in an *Avicennia-Batis* salt-marsh association on the river side of the offshore island beach-strand on the east coast of Florida and about 1/4 mile north of the line separating St. Lucie and Indian River Counties. "Hob Horse Cove" area is ecologically similar to the Dead Forest at Sanibel. The exodus study area lies along the west side of the oak-palmetto zone which gradually slopes upward to the sand dunes which extend 1/4 mile beyond to the Atlantic Ocean.

A natural seepage area occurs at the juncture of the upland oak-palmetto zone and the transition zone. Here are found the usual *Conocarpus erectus* (buttonwood), *Laguncularia racemosa* (white mangrove) and *Batis maritima* (pickleweed). Spring and wind tides flood the marsh up to this juncture. Extending westward there is a narrow sandy salt flat about eight feet in width, on either side of which *Batis* grows luxuriantly to a height of two feet or more. The sand flat and the *Batis* together form an open treeless area 18 feet wide by 100 feet long. To the south the open area abruptly joins some very large black mangroves and on the north it merges into a red mangrove (*Rhizophora mangle*) thicket. Between the black mangroves (to the south of the sand flat) the soil is soft silty peat and supports a thick growth of *Batis* in the sunny spots. It was in this vicinity that part of the large emergence took place and the following descriptions of exodi were observed. West of the sand flat for 150 to 200 feet there is a dense black mangrove forest, 35 to 40 feet high; the long axis running in a general north-south direction. The irregular forest floor in the most densely shaded or pot-hole areas contains only leaf litter, dead branches and numerous pneumatophores, but in sparsely shaded or dead tree areas *Batis* has invaded from the margins of this zone. Immediately west of this forest lies a wide (1/4 mile) expanse of *Batis* marsh, dotted here and there with

orchard shaped, squatty trees no more than 15 to 18 feet high. All of these marsh plant communities held a high *A. taeniorhynchus* egg index (which had been deposited over a period of more than six weeks). It was from this entire marsh area that the brood described below resulted.

On Sunday, August 7, 1955, Hurricane "Connie" passed east of Vero Beach, 500 miles out to sea. The huge ground swells caused by the storm resulted in high tides which flowed into the inlets at Ft. Pierce, Stuart and Sebastian, causing the interior lagoon, viz., the Indian River, to overflow its banks. By August 9 and 10 the whole marsh was covered with 10 to 18 inches of water which hatched most of the viable eggs on the marsh. All flooded marsh areas on both sides of the river were teeming with large larvae on August 13. Pupation started in the Hob Horse Cove area on August 14 between $14^h30'$ and $16^h00'$.

The first day of emergence was well on its way at $10^h00'$ on August 16, with peak emergence about $11^h30'$. A collection of 500 of these adults revealed that the sex ratio of this emergence was 15 ♂ to 1 ♀. At $16^h30'$ the water temperature was 30° C. and the air temperature 28.5° C. At $16^h45'$ the older individuals were observed climbing, by short flights, into trees up to about 8 feet above the *Batis* and pneumatophore resting sites near the ground, and by $17^h15'$ many had reached the 15-foot elevation among the tree branches. There were almost no flowers at the emergence resting sites, only a few flowers of *Conocarpus* being present while the *Avicennia* blossoming season was past, so that nectar feeding prior to the exodus could not be observed for this brood.

a. FIRST EXODUS OF BROOD III. Sunset was at $18^h59'$ and the exodus started 16 minutes later at $19^h15'$. The initial waves of adults leaving the branches were very small, but soon a loud hum filled the air as larger waves became airborne. At $19^h20'$ when a dark cloud came over and obliterated the sky overhead (leaving only a thin area of sunset in the west), they started leaving *en masse* by $19^h30'$, probably because the light was lowered so rapidly (see Fig. 3). By $19^h35'$ no mating had been seen and no swarms of males formed. A dead calm prevailed and there was a hush over the land; the high pitched singing above the trees which was heard at Sanibel after the first night of exodus was missing here. From $19^h30'$ to $19^h45'$ adults feeding on the few *Conocarpus* flowers were studied and counted, there were 46 ♂ ♂ and 2 ♀ ♀. There were some adults biting at the edge of the hammock but out in the marsh proper there were very few biting. Apparently the biting mosquitoes were not from this area.

August 17 was the second day of this large emergence. I arrived at $10^h00'$ and already there were several million adult mosquitoes resting on the vegetation to an elevation of about 3 feet; in many cases both sides of the leaves of *Avicennia* seedlings were occupied, the undersides being completely covered with mosquitoes. There were three species of warblers engorging on the young adults resting on red mangrove trunks and roots, and in an open spot a sandpiper was making a meal of those resting on fallen leaves. The numerous rafts of pupae and larvae ranged in size from 10 × 12 feet to 20 × 40 feet (a raft of pupae consists of dense aggregation of 4th stage larvae and pupae which remain together and emerge at focal points among emergent vegetation, roots or leaves). Small fish were numerous and very voraciously feeding along the outside edges of these rafts. Whenever a minnow found itself enclosed by a portion of the raft of bobbing pupae and larvae it would immediately become unusually nervous and dash for open water. This rafting or balling-up seemed to serve as a protective device against aquatic predators.

Between $10^h30'$ and $11^h25'$ the greatest peak occurred. The surfaces of the rafts were now literally blanketed with newly emerged adults resting (while their wings dried) on the pupal skins and even on the backs of other pupae which were ready to emerge themselves as shown by their inactivity at the water's surface (see Fig. 1). All of the rafts in the vicinity had been

measured by 12h55′ and the percent emergence of each recorded; many rafts were 100 percent emerged at this hour.

b. Second Exodus of Brood III. Mr. E. J. Beidler (Director, Indian River Mosquito Control District) assisted me in this set of observations. At 19h00′ many of the mosquitoes had ascended to a height of 6 feet into both black and red mangrove trees and ten minutes later they had reached 15–20 feet into the branches and tops of some trees. All at once at 19h12′ (14 minutes after sunset) the exodus started, with adults flying off branches and ground vegetation, going almost straight up until they were flying close to, but above the tree canopy. A few matings were seen when only small waves of mosquitoes were rising from the *Batis* plants and passing in front of the observers standing on the ground. Suddenly at 19h13′ (one minute after the exodus started) a massive movement of ascending mosquitoes began to almost darken the sky. This flight activity was observed for four minutes. The participants were scrutinized for further copulations, but no more were seen after the first minute of exodus. At this time, 19h17′, the author climbed a large black mangrove tree for closer observation of the flight above the trees. It was soon seen that the flight immediately above the observer's head consisted of a great band of millions of mosquitoes, all moving in unison on a southward upwind course (wind so low, almost imperceptible) in a compact undulating mass-flight. This band appeared to be 2–4 feet in thickness, vertical aspect, whereas the east-west width could not be ascertained (probably several hundred feet wide corresponding to the width of the principal north-south emergence area). Figure 4 shows the relative position and unidirectional southward upwind flight in relation to the vegetation of the marsh. It could best be compared to a huge belt or tread of a caterpillar tractor moving on rollers over the tops of the trees, only missing them by a few inches and dipping down between. At this time the air temperature had dropped about 2° C. below the 16h00′ reading of 31° C., a bright band of sunset sky remained to observe against, and a trace of air continued to come from the south (as tested by a wet finger). This migration had its maximum boost at 19h20′ or 8 minutes after the migration started. A sample of the migrating stream of mosquitoes was taken by sweep net at 19h23′ from above the tree in which the author was standing. Later, about 50 of these were examined; all were *A. taeniorhynchus;* and the ratio of males and females was almost exactly 50:50. At 19h25′ the exodus was over, the migrants had com-

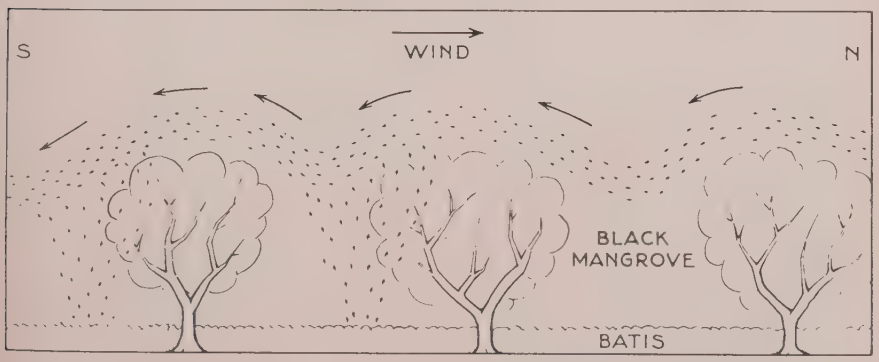

Fig. 4.—A schematic representation of the *Aedes taeniorhynchus* ascent and exodus and actual start of migration above the black mangrove trees.

pletely disappeared, and all was quiet in place of the high pitched, frenzied humming of millions of wingbeats. It was as if the observers had walked into a soundproof room. It was difficult to realize that we had actually seen a portion of the migration and that it took a definite direction of flight. Apparently no swarms formed and no high pitched singing could be heard after the migration was over, comparable to that observed at Sanibel Island on the first night at the Dead Forest study area. The *Batis* ground cover still contained a few thousand mosquitoes not yet old enough to leave.

The observation of this well-defined directional migration was possible because the location of the observation post was several hundred yards upwind of a large percentage of the breeding area. If the departing individuals had all left from the observation point, as in the other cases, this would never have been seen. The vast majority of males were too young for mating to take place.

c. THIRD EXODUS OF BROOD III. On this third day of emergence it was estimated that about 10 million adults had emerged by 13^{h}00′. This day's emergence was not observed systematically as the two previous days were, but it is assumed that it followed about the same pattern. On this day Messrs. Beidler and Oscar Fultz came along to observe the exodus. On the way to the marsh large black clouds were noticed south of the emergence area. Presuming that this clouded condition (by lowering the light intensity) might hasten the ascent and the departure I drove to the observation point as quickly as possible. At 18^{h}50′ as the party walked through a glade of *Bidens* and *Eupatorium* at the trailside (75 feet east of marsh) hundreds of *A. taeniorhynchus* of both sexes (from emergences of two previous days) were feeding on nectar in the flower heads of 6–7 feet tall *Eupatorium* plants. After watching the nectar feeding for three or four minutes we went on to the breeding area 150 feet to the west. It was now 18^{h}55′ and the large black cloud to the south and west was obscuring the sunset. At this hour many of the mosquitoes were already in the black mangrove trees and a few had begun to leave. The first departure occurred 17 minutes earlier than the evening before when no clouds were present. This was undoubtedly due to the reduced illumination. Five minutes later at 19^{h}00′ (2 minutes after sunset) they were leaving *en masse*.

Two observers stayed on the ground while the author climbed the same black mangrove tree from which he observed the directional flight the evening before. Those adults which left from resting sites in the tops of 2 feet high *Batis* plants left directly from there without first climbing the trees for the take-off. The same phenomenon had also occurred on the previous two evenings, but not quite to the same extent. As during the previous two twilight exodi the ascending adults hit the observers' faces like windblown raindrops. These adults flew almost straight up without stopping in the trees, their flight was sustained from the moment of take-off to joining of the swarm above the tree canopy. The weather was now blustery, the large moving swarm was not going in any one direction but undulated and swirled in the air currents. There was a tremendous singing hum, varying in its intensity, like vibrating echoes. By now it was too dark to see in what definite direction, if any, the migratory swarm was carried. Probably it was carried some distance to the northeast since the wind was generally from the southwest at about 12 miles per hour. By 19^{h}05′ all was quiet again and the wind had died down. Before I climbed down from the tree perch, small top swarms were forming over the branches of *Avicennia* and *Conocarpus* trees at an elevation of 25 feet. Flower feeding was again observed from 19^{h}07′ to 20^{h}00′ at the glade east of the marsh. Both sexes were now feeding at a greatly accelerated rate on both *Eupatorium* and *Bidens* flowers. No resting adults were left in the *Batis*. At 20^{h}00′ a strong south wind developed and continued to blow from that direction most of the night.

By 12^{h}30′ the next day, August 19, the

water had receded from the marsh because the south wind had blown it northward upriver. The pupae left along the perimeter of the marsh were stranded among the windrowed mangrove leaves and on the mud in the trails. At 19h10′ the evening before numerous fish were taking their toll of the larvae remaining in the few puddles, and now none could be seen. The only evidence of the brood was a small emergence from pupae stranded among moist leaves. Some of these new adults were swept up and found to be almost all females, and it is interesting to note that they were smaller than the previous day's adults. Older adults from the previous day's emergence were feeding during the middle of the day (12h40′) on the *Eupatorium* flowers.

Brood IV. Hob Horse Cove

This brood hatched September 9, 1956 and was just about as large as that produced in August, 1955.. It was flooded in synchrony by high tide and rain in the same marsh as Brood III. The entire month of August had been extremely dry and adults from a July brood had oviposited millions of eggs over the entire area. On September 17–19 there were large emergences but twilight observations were prevented because of rains. On September 20 Messrs. W. L. Bidlingmayer, M. W. Provost, and the author observed a large departure of imagines from the *Batis-Avicennia* area located 200 yards west of the tall *Avicennia* zone to the east. We were trying to determine the direction the imagines would fly in relation to wind and also to get pictures of the departing migrants (see Fig. 3). The sky was entirely overcast and a light drizzle was falling during the observations.

At 18h00′, 21 minutes before sunset, the migrants started to depart in waves as already described for other exodi; they were leaving directly from the *Batis* as well as from a dead tree upon which many had climbed. The light intensity was low at an early hour because of the overcast weather; the temperature was 27° C. Most of the adults took off facing the wind but, since it was too strong for them to make headway, soon turned around and flew with it. At 18h25′ the initial departures were over, leaving great numbers of imagines resting in the *Batis;* most of these were apparently not old enough to leave. The wind was from the northeast at 3 to 5 miles per hour and the migrants traveled SSW, more or less with the wind. They attained altitude on an angle of approximately 45° from the point of origin and seemed to level off at about 20 feet elevation. At 19h00′ the air temperature was 26° C. It was decided to see if the imagines still remaining could be induced to depart from the *Batis* plants on which they were resting, by disturbing the plants. While Mr. Bidlingmayer was stationed 30 to 40 feet downwind Dr. Provost would periodically flush a host of adults—many of which would depart, flying downwind over Mr. Bidlingmayer's head at 8 to 15 feet elevation above the marsh. It was now 19h15′ and dark. Mr. Bidlingmayer's flash-light was shone upwards to intercept the imagines as they passed overhead. It was difficult to tell if many were flying at elevations higher than 15 feet. As they passed him, at this hour, he estimated that they were flying at angles between 16° and 20° from the point of take-off. A good many of the adults immediately returned to the *Batis* when disturbed. No mating was seen though it was not looked for specifically.

This was the fifth day of emergence and male swarms were over every small tree in the vicinity of the observation area. The air was literally teaming with mosquitoes when the electronic flash was shot skyward. These were flying, "milling around," even at 30 to 40-foot elevations.

Discussion

The work of the Entomological Research Center previously reported in quoted papers by Provost and Nielsen showed that *A. taeniorhynchus* was migratory during the early period of adult life. The combination of adult age and time of the day determined the time of migratory exodus

from the breeding site. The observations reported in this paper have corroborated the previously published knowledge and added information on several points.

(1) Newly-emerged mosquitoes will feed on nectar before and during the ascent if such food sources are available. If nectar is not available, the exodus will take place anyhow but obviously a nectar meal before the exodus may have a considerable effect on the range of migration. The importance of carbohydrate food has been discussed by Hocking (1953), and it should be borne in mind that the reserves carried over from the developmental stages in the form of fat and glycogen are not immediately available for a migratory flight; only carbohydrates can be utilized for immediate use (Wigglesworth, 1950) while the mobilization of fat takes time. It is therefore reasonable to assume that mosquitoes have a much greater potential flight range when nectar is abundant at the breeding sites, as is the case during the flowering period of the black mangrove in spring and early summer.

(2) The second point of importance obtained from these observations is the increased knowledge concerning their sexual behavior. The concept previously arrived at—that females may copulate as soon as they can make extended flights (the copulation is always initiated in flight) and that the males are of a certain age before they can mate—also holds true with *A. taeniorhynchus*. During the several exodus periods described it was directly observed that a very large number of matings occurred in some cases, while in others there were few or none taking place. This may be explained by the presence or absence of males of sufficient age for copulation, e.g. with a hypopygial rotation of 135° (12–18 hours or even as young as 10 hours) (Nielsen, 1958).

(3) Nielsen (1958) pointed out that his observations only dealt with the habits of the animals up to the very point of exodus, when they disappear to a ground observer. During the observations reported here it has been learned that in some cases the potential migrants will remain flying around above the emergence site for some time after the exodus. This takes the form of a swarm-like flight which may be comparable to the "milling-around" before migration, known from the work by Gunn *et al.* (1945, 1948) and Kennedy (1951) on locusts and the butterfly *Ascia monuste* by Fernald (1937). Sometimes this "milling-around" is not visible from the ground but can be heard as a characteristic high pitched humming which can stop very suddenly as the animals disappear from the area. The author heard this on August 19, 1951 on Sanibel Island, and both saw and heard it on April 22 and May 21, 1953 on Sanibel Island and on September 20, 1956 at Hob Horse Cove. The conditions under which the "milling-around" occurs, during and after an exodus, are unknown.

(4) In other cases the migrants take off on a very determined flight with all animals flying in the same direction, this direction probably determined by wind. At low wind velocities (1/4m./sec. or less) the flight was oriented upwind; at higher wind velocities (1-1/2–2 m./sec.) the flight was downwind. There is a suggestion here of possible optomotor accommodation along the lines hypothesized for *Aedes aegypti* (Linnaeus) by Kennedy (1939).

(5) The exodi of April 22 and May 21, 1953, on Sanibel Island took place during dead calms and were oriented toward the sunset sky. This apparent visual orientation of exodi is reminiscent of locust orientation of swarm departures by the sun, when it is calm (Kennedy, 1951); the locusts, however, depart at 90° to the sun because that is how they orient to bask before the exodus, in other words, the orientation is not directly visual.

SUMMARY

The flight behavior patterns of migrant *A. taeniorhynchus* during the exodus from the breeding sites are described for four large emergences.

It was found that feeding on nectar takes place before exodus if flowers are

present, and that matings occur during the exodus if males are old enough to copulate. Under certain unknown conditions the potential migrants "mill-around" high up in the air, both during and after exodus and presumably before the migratory flight begins.

The directional flight of the migrants was observed visually for the first time.

The direction of the departing migrants seems to be determined mostly by the wind, being upwind in wind velocities of 1/4 m./sec. and downwind in wind velocities over 1-1/2 m./sec.

In the one instance of the mosquitoes flying towards the sunset the weather was calm with no leaf movement at the top of the trees but it is not known if there were imperceptible air currents above the trees which influenced the flight direction.

Acknowledgments

This study covers a period of five years and many people have been helpful in making these observations possible. It is with gratitude that I acknowledge the cooperation, interest and encouragement of Dr. Maurice W. Provost and Dr. Erik Tetens Nielsen, both in the field and during the many lengthy discussions on the subject at hand. Thanks also to them for reviewing the manuscript.

Others who have accompanied me on observations and helped in many ways are Mr. William L. Bidlingmayer, Mr. E. John Beidler, and Mr. Oscar Fultz.

Last but not least, many thanks are extended to Miss Helle Starcke for correcting and preparing the final manuscript.

References

Fernald, H. T. 1937. An unusual type of butterfly migration. Florida Ent. 19:55–57.

Gunn, D. L., Perry, F. C., Seymour, W. G., Telford, T. M., Wright, E. N., and Yeo, D. 1945. Mass departure of locust swarms in relation to temperature. Nature, Lond. 156:628–629.

——— *et al.* 1948. Behaviour of the desert locust (*Schistocerca gregaria* Forskål) in Kenya in relation to aircraft spraying. Anti-Locust Bull. No. 3, 70 pp.

Haeger, J. S. 1955. The non-blood feeding habits of *Aedes taeniorhynchus* (Diptera, Culicidae) on Sanibel Island, Florida. Mosquito News 15(1):21–26.

———. 1958. The colonization of *Aedes taeniorhynchus* Wied. (Diptera, Culicidae). Proc. N. J. Mosq. Ext. Ass. 45th Ann. Mtg., pp. 80–88.

Hocking, B. 1953. The intrinsic range and speed of flight of insects. Trans. R. ent. Soc. Lond. 104(8):223–345, illus.

Kennedy, J. S. 1939. The visual responses of flying mosquitoes. Proc. zool. Soc. Lond. (A) 109(4):221–242, illus.

———. 1951. The migration of the desert locust (*Schistocerca gregaria* Forsk.). I. The behaviour of swarms. II. A theory of long-range migrations. Phil. Trans. (B) 235(625):163–290, illus.

Nielsen, E. T. 1958. The initial stage of migration in salt-marsh mosquitoes. Bull. ent. Res. 49(2):305–313, illus.

——— and Haeger, J. S. 1954. Pupation and emergence in *Aedes taeniorhynchus* (Wied.). Bull. ent. Res. 45:757–768.

——— and ———. 1960. Mating and swarming in mosquitoes. Misc. Publ. ent. Soc. Amer. (in press).

——— and Nielsen, A. T. 1950. Contributions towards the knowledge of the migration of butterflies. Amer. Mus. Novit. No. 1471, 29 pp., illus.

——— and ———. 1953. Field observations on the habits of *Aedes taeniorhynchus*. Ecology 34(1):141–156, illus.

Provost, M. W. 1952. The dispersal of *Aedes taeniorhynchus*. I. Preliminary studies. Mosquito News 12(3):174–190.

———. 1957. The dispersal of *Aedes taeniorhynchus*. II. The second experiment. Mosquito News 17(4):233–247.

Smith, J. B. 1904. Report of the New Jersey State Agricultural Experiment Station upon the mosquitoes occurring within the State, their habits, life history, etc. Trenton, N. J.: MacCrellish and Quigley, v + 482 pp.

Wigglesworth, V. B. 1950. The principles of insect physiology. London: Methuen and Co., Ltd., viii + 546 pp., illus.

THE DISPERSAL OF *AEDES TAENIORHYNCHUS*

III. STUDY METHODS FOR MIGRATORY EXODUS

MAURICE W. PROVOST [1]

Earlier studies of brood dispersal in *Aedes taeniorhynchus* (Provost 1952, 1957) had supported the thesis ascribing ultimate dispersal in migratory mosquitoes to an initial non-appetential or non-searching migration and to subsequent appetential or searching flights (Provost 1953). Subsequent investigations by members of this laboratory have confirmed the occurrence of special migratory flights initiated at the emergence site in a departure referred to as a migratory exodus (Nielsen 1958; Nielsen and Nielsen 1953; Nielsen and Haeger 1960; Haeger 1960). Methods of studying the migratory exodus, other than the important unaided observation, were especially advanced in two experiments on the east coast of Florida, one near Fort Pierce in which the mosquitoes were marked and the other near Vero Beach with unmarked mosquitoes. These two experiments are here described for the primary purpose of placing on record the techniques applied to the problem of mosquito dispersal at this laboratory.

A. THE FORT PIERCE EXPERIMENT

In the summer of 1952 an exodus study was undertaken in Ft. Pierce on the mid-east coast of Florida in combination with a study of marking techniques. Larvae were to be marked with radioactive phosphorus (cf. Provost 1952, 1957) and the resulting radioactive adults, in smaller groups, with aniline dyes in the dust formulation used by Clarke (1938). The experiment yielded valuable information on (1) mass egg production, (2) rearing technique, (3) marking with radioactive phosphorus, and (4) capture of adults in stationary nets at exodus.

1. *Egg Production*

The method of sod-transfer used in our second dispersal test on Sanibel Island (Provost 1957) was used and circumstances forced us to bring the egg-laden sod here from Sanibel, 180 miles away. But Sanibel Island by midsummer was all under water with no readily available egg deposit, although adult mosquitoes were phenomenally abundant. It was decided to drain an amenable area and thereby induce the adults to lay eggs there. The "Duck Pond" was selected, the same area from which sod had been taken for the June experiment (q.v.).

On July 15 an earth dam was thrown up to dike off a 250-foot length of swale and a ditch dug down the center of the narrow swale. Near the road a sump was dug 3–4 feet deep and 5 feet in diameter. A small pump was then set up which pumped the water out of the hole and delivered it across the road. It took ten days of almost continuous pumping to remove the standing water and the water seeping in through and under the dikes. During the two weeks of pumping, July 24 to August 7, rains were frequent.

On August 4, samples of the *Philoxerus vermicularis* sod averaged 2383 eggs per square foot. The sod for transfer to Ft. Pierce was cut off by shovel in approximately square-foot chunks about three inches thick. It was placed on 80 2x8-foot masonite litters. The litters were stacked on two flat-body trucks. The 1280 square feet contained an estimated three million eggs. The sod remained on the trucks in storage until September 5. Testing showed unappreciable loss of viability in these eggs over the 32 days of storage. Small portions of the sod were retained after the Ft. Pierce experiment. After five months there appeared to be little loss of eggs. By the sixth month, however, a great loss of via-

[1] Contribution No. 89, Entomological Research Center, Florida State Board of Health, aided by grants Nos. 1408 and 1492, National Institutes of Health, U. S. Public Health Service.

bility had occurred, most eggs having collapsed.

2. *Larva Production*

The marking was done at a grassy clearing surrounded by salt marsh and mangrove on the eastern shore of the Indian River some five miles northeast of Ft. Pierce. This meadow on the McConville property was described in detail by Nielsen and Nielsen (1953) in their initial paper on the behavior of *Aedes taeniorhynchus* (q.v.).

A special larval nursery ditch was dug by dragline on the very edge of the Indian River so that a small pump could move water either out or into the ditch, a high dike being thrown around it to keep out any possible high water. The ditch was 15 feet wide and 80 feet long, oriented east-west, with the bottom 18 to 24 inches below the ground level at the site. A sump three feet deep was dug along the west or river side to facilitate pumping. On September 4 the pumping was begun into the river, aimed at having the ditch bottom free of water before dawn of the next day.

The plan called for producing two larval broods spaced 8 hours apart at egg-hatching. On September 5 at $05^h30'$ one truck-full of egg-laden sod was laid, like a lawn, on the eastern half of the ditch. The transfer of 640 square feet of sod from truck to ditch took one hour. The sod on all but the uppermost litters was quite moist but the vegetation (mostly *Philoxerus*) was all yellowed. There was evidence of mildew on the sod but no disagreeable or acid odors. One difficulty encountered was that the soil had glued itself to the masonite so that machete blades had to be run under the dirt to facilitate sliding the sod off.

As soon as the sod was all in the ditch, a dike was built separating the ditch into two pools, and the one just filled with sod became Pool I. The pump was reversed and water brought into Pool II. When the water was a foot deep the cross-dike was broken at one end and all the water allowed to flow over the sod in Pool I. The dike was then repaired and another foot of water added to Pool II, and the procedure repeated. This was done until the water in both pools was close to the surface of the ground. In this manner there was always a strong current from Pool II to Pool I, making it impossible for any early hatching larvae to work their way into Pool II. At $09^h00'$ the cross-dike was about 8 inches above the water table. All the sod in Pool I had been flooded between $08^h07'$ and $08^h30'$.

At $14^h30'$ the pump was started and drained Pool II. Again it took about an hour to transfer the sod from the second truck to the ditch bottom. The pump was reversed and Pool II was filled with water from the Indian River. The sod in Pool II was all flooded between $16^h02'$ and $16^h30'$. The water was left at the same level as that in Pool I. It was noted at this time that the water in Pool I, having stood in the sun eight hours, was much warmer than the water just introduced into Pool II from the river.

In Pool I some eggs hatched almost immediately on flooding but it was apparently several hours before the hatch was complete. The hatch was not nearly as synchronous as was the case in the Sanibel experiment in June (Provost, 1957) although actually the flooding was much quicker in the present case. The 8-hour initial lag of Pool II behind Pool I seemed to increase from the standpoint of larval development as time went on, probably because the 8-hour advantage of Pool I was during the heat of the day.

The shallow, warm water resting on the rich organic substrate from which the eggs had hatched resulted in a food-rich situation in which the larvae grew apace.

3. *Marking Methods*

Hurricane threats forced us to postpone the experiment twice. The 80 mc of P^{32} shipped from Oak Ridge on the morning of August 25 arrived at Vero Beach, by air, Tuesday morning, August 26. The acid was diluted to one liter on the afternoon of September 8 and divided into three equal portions for field use.

At $15^h00'$ on September 8 the larvae were seined out of Pool I and placed in tanks A and B. These were wooden troughs $6' \times 3' \times 8''$. The seining was done as it had been done on Sanibel Island in June (Provost 1957). A lot of broken and loose vegetation was unavoidably transferred also and most, at least of the large pieces, were removed thereafter. By $18^h00'$ it was estimated that each tank held 250,000 larvae in about 5 inches of water. The P^{32} was introduced into tanks A and B at $18^h30'$ and $18^h40'$ respectively.

On September 9 at $05^h30'$ the first task was to set up tank C approximately 30 feet away from tanks A and B. Then 4-1/2 inches of water from Pool II were put into it and the seining of larvae from that pool to the tank was begun. The larvae were balled up in the pool; this permitted seining from the bank, so that much less vegetation and trash were transferred to tank C than had been to tanks A and B. At $07^h45'$ it was estimated that between five and six hundred thousand larvae were in tank C. More seining was done until a good estimate indicated 600,000. The P^{32} was introduced at $08^h15'$.

By the time it was used, the P^{32} had so decayed that tanks A and B received 13 mc each, and tank C, 12-1/2. With 5 inches of water in the tanks, the initial P^{32} dosage became .065 μc/ml in tanks A and B, and .063 μc/ml in tank C but .052 μc/larva in tanks A and B, and .021 μc/larva in tank C. The latter tank therefore compared favorably with two of the tanks on Sanibel Island in June where the dosage was .077 μc/ml and .022 μc/larva. However the latter produced adults yielding 500 CPM for males and 2,000 CPM for females, whereas the adults for tank C of this experiment yielded adult activities of 4,377 CPM in males and 6,371 in females. The causes for this great difference will be discussed below. In tanks A and B of the present experiment the adult activity at emergence was 6,428 CPM in males and 10,866 CPM in females. By final comparison, in the August 1951 experiment on Sanibel Island (Provost 1952), dosages of .066 to .101 μc/ml but adjusted to .019 μc/larva yielded adults which at emergence had activities averaging 715 CPM for males and 3200 CPM for females.

In the 1951 experiment (*q.v.*, Provost 1952) water and larvae from each of the four tanks were placed into five beakers per tank immediately after introduction of the P^{32} into the tanks, and both water and larvae were monitored every six hours from all four tanks and twenty beakers. This study revealed that ingestion of isotope was proportional to dosage per water unit and not to dosage per larva, which is logical. Monitoring of pupae, pupal skins, and adults showed that the skin's activity was only 8.3 percent of the adult in the female, compared to 15.6 percent in the male—evidence that the usual higher activity of the adult female is the result of her greater feeding activity in the larval state. It was also demonstrated then that larval increments of radioactivity per time unit were proportional to larval size. In this 1951 experiment the larvae became hungry and two of the four tanks were fed dog biscuit. The maximum larval radioactivity was 7,500 CPM before feeding and 9,500 CPM after feeding. In the unfed tanks the same maximum, 9,500, was reached, but two days later. One unfed tank was retained for observation after the big emergence and all larvae eventually died, with no further pupation. A further finding of the 1951 experiment was that 16 percent of total adult radioactivity was in the legs, while the percent activity in the head-thorax-abdomen was 12–61–11 for males and 6–31–46 for females. While the total ratio of radioactivity in females over males was 5 to 1, it was 2 to 1 in the head and thorax and 22 to 1 in the abdomen.

Returning to the Ft. Pierce 1952 experiment, by $09^h00'$ of September 9 the larvae which had been overnight in tanks A and B showed pronounced signs of hunger, and by $11^h00'$ so did those in tank C after only three hours in that tank. All were fed ground dog biscuit. By late September 11, 50 ounces of dog

biscuit had been fed these larvae or 1.3 mg per larva. This heavy feeding was the result of transferring the larvae from pools to tanks in the late third instar instead of in the early or middle fourth instar. It also accounted for the high activity of adults compared to the June experiment on Sanibel Island when the transfer was when they were 16 to 24 hours old as fourth instars (Provost 1957). The record of feeding in the three tanks is shown in Fig. 1, showing the accompanying rise in larval radioactivity.

avoidably in a necessarily low P^{32} dosage, transferral in the third instar may be necessary for good marking. If sufficient P^{32} is on hand, however, good marking with little or no feeding and much reduced mortality can be better achieved by delaying transferral to the tanks until the larvae are well into the fourth instar and compensating by an increased P^{32} dosage.

4. *Exodus Study Methods*

By noon of September 10 pupation had advanced to 50 percent in the warm waters

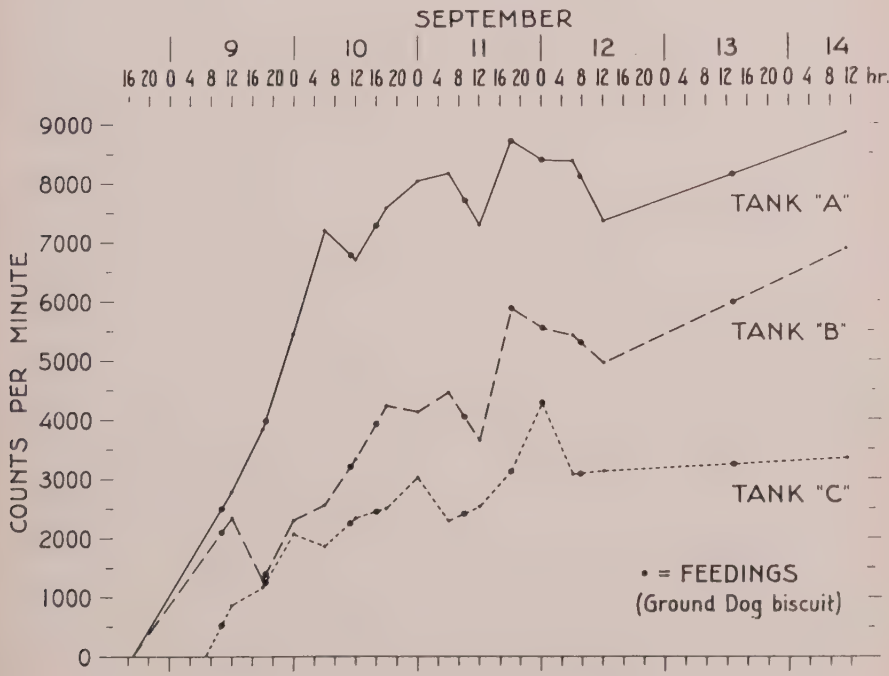

FIG. 1.—Uptake of radioactivity by *A. taeniorhynchus* larvae in three tanks. Ft. Pierce, 1952.

The experience of three radioactive-marking experiments leads us to the following conclusions. Transferral from pools and natural food to tanks for radioactive-marking may be done either in the late third or fourth instar. The earlier it is done the more artificial feeding will be necessary and the greater will therefore be the threat of mortality in the tanks. If the exigencies of the case have resulted unof Pool I but only to 10–25 percent in the shaded tanks A and B. No pupae were found in Pool II and in tank C. Because of feeding complications, heavy rains, and the failure of dyeing methods it proved impossible properly to follow the course of pupation in the tanks. Adult emergence began on September 12, with a minor exodus that evening at twilight. There was a larger exodus at twilight on Sep-

tember 13 and a slightly lesser one at twilight on September 14. Observations of behavior during exodus, including the first observation of mass mating, are reported elsewhere (Haeger 1960).

Recovery of marked mosquitoes for the first few days of exodus was attempted by stationary nets, at the meadow discussed below, and by the usual truck traps, rotor traps, and light traps within five miles. Three rotor traps, three truck traps, and 12 light traps were in operation. In addition a large funnel mounted on a fast boat was operated up and down the Indian River for two miles north and south of the release point. It caught no marked mosquitoes. An attempt was made to sample the air 50 to 100 feet up by a Piper "Cub" plane equipped with funnel nets. This also proved abortive.

The June experiment on Sanibel Island had convincingly shown that the insects in the process of migrating could not be adequately sampled by any of the common collecting devices: light traps, truck traps, or bait traps. The rotor trap 40 feet from the tanks did catch departing migrants, however, and taught us that at least the migratory exodus could be better studied with collecting devices.

For the Ft. Pierce experiment, we employed the stationary nets described by Nielsen (1960). The large funnels are specially designed to trap wind-borne or migrant insects while not retaining many insects in ordinary searching flights. Four pairs of these two-meter square nets (Fig. 2) were mounted, one pair as near as terrain permitted in each of the four cardinal points, 75 feet from the tanks and facing them. The low net was centered 6 feet above the ground and the upper net, directly above it, 15 feet above the ground.

Collections made at various hours of the night with these traps are summarized in Table 1. There was a very high density of wild, unmarked mosquitoes on the meadow, making all work there very painful unless repellents were used. Not having operated a rotor trap there (no electricity), however, we had no measure of the ratio of newly emerged, marked mosquitoes on the exodus nights to the wild, unmarked mosquitoes. For the three successive nights of operation the percentage of mosquitoes marked, in the stationary nets, was (♂ — ♀) : 89–1, 47–14, and 49–31 for a total of 56 percent of the males and 18 percent of the females. The unmarked could have represented some escapes from the rearing pool residual which we had unwisely not destroyed. The lower nets yielded a higher percentage of marking in the males than the upper

TABLE 1.—Captures of *Aedes taeniorhynchus* in stationary nets, September 12–15, 1952. Ft. Pierce experiments

		Directional									
		N		E		S		W		Total	
		Lo	High	Lo	High	Lo	High	Lo	High	Lo	High
♂	wild	5	3	5	2	11	49	1	3	22	57
	marked	6	1	14	2	21	42	9	6	50	51
♀	wild	53	12	73	21	35	55	31	35	192	123
	marked	1	0	4	0	12	50	0	2	17	52
percent marked	♂	55	25	74	50	66	46	90	67	70	47
	♀	2	0	5	0	26	48	0	0	8	30

♂	wild	8 7 60 4 79
	marked	7 16 64 14 101
♀	wild	65 94 90 66 315
	marked	1 4 62 2 69
percent marked	♂	47 69 51 79 56
	♀	2 4 41 3 18

FIG. 2.—Stationary nets as set up for interception of mosquito exodus.

nets, whereas this difference was pronouncedly reversed in the females. The sex ratio in the upper nets, 39 percent males, compared to the lower nets, 26 percent males, seemed to indicate a higher flight for the males, but this conclusion was thrown in doubt by the much higher percentage of males in the lower nets among the marked mosquitoes, 75 percent *vs.* 50 percent. With respect, therefore, to height of migratory flight, the stationary nets yielded inconclusive data, but the possibilities of the method were shown to be excellent.

With respect to direction of exodus, the stationary nets showed themselves most useful. The nets were slightly clock-wise deviant from the cardinal points, so that the south net was actually SSW. The wind during the exodus nights was NE. Disregarding heights, the percentage of total marked catches in the south net was (64/101) 64 percent for males and (62/69) 90 percent for females, indicating a strong downwind displacement. The unmarked, as percentages, were 10 percent N, 9 percent E, 76 percent S, and 5 percent W for males and 20 percent N, 30 percent E, 29 percent S, and 21 percent W for females. The unmarked males followed the same southerly trend as the marked mosquitoes, but the omnidirectional trend of the unmarked females suggested that searching flights of older, non-migrating females were the source, this being borne out by their preponderance in lower nets, 192 out of 315 or 61 percent so caught. The probable reconstruction is therefore that migrants of both sexes went downwind and were mainly intercepted by the upper nets, whereas the older non-migrant females were about their searching flights in all directions and were mainly intercepted by the lower nets. The unmarked males, most likely newly emerged from the breeding pools, also went downwind and were caught mostly (72 percent) in the upper nets. These conclusions are highly speculative and are given only to emphasize the potential usefulness of these stationary nets.

By contrast with the results obtained at the meadow, distant collecting methods were quite unsuccessful. Truck traps (cf. Provost 1957) operating throughout the exodus nights over three routes within five miles of the meadow yielded only three marked specimens, a female on the beach road within 2 miles of the meadow to the southeast (Sept. 15 between $06^h00'$ and $06^h10'$), a male on the river road 2 miles southwest (Sept. 15 between $05^h50'$ and $06^h02'$), and a second male on the ridge road 3 miles west (Sept. 14 between $05^h29'$ and $05^h37'$). Three rotor traps, 2 miles north, 2 miles southwest, and 2-1/2 miles southeast, operating all night yielded no marked mosquitoes. The light traps yielded marked females only, and these only starting the third night after the first exodus when 13 were recovered. On the fourth night 31 were caught, on the fifth only 2. The traps were not run beyond this as we were not studying the ultimate dispersal. Directionally, 34 out of 46 marked females recovered, or 74 percent, were north; 8 were south, 2 southeast, and 2 west. There is no indication that this distribution reflects the final distribution, as the twilight exodus three nights in a row indicated a very likely migration far beyond the light traps operated, especially to the southwest.

B. The Vero Beach Experiment

In October 1958 an experimental study of a natural *Aedes taeniorhynchus* emergence near the laboratory was undertaken as a test of various exodus study techniques to be employed in future dispersal experiments. The emergence was in a half-acre slough grown mostly to Sea Oxeye (*Borrichia frutescens*) and surrounded by cabbage palms, oaks, and other medium-sized trees. The hatch resulted from the wind-blown spring tides of October 7 and 8. Water temperatures averaged 24° C. during the larval period. Pupation started on the morning of October 13. The weather was very uniform during the main pupal interval, October 13–16, with water temperatures varying little from 25° C. Using information now available on pupal duration (Nielsen and Evans, MS) and age at

FIG. 3.—Kytoon net for upper-air sampling of mosquito exodus.

exodus (Nielsen, 1958; Haeger, 1960) it was predicted that the first emergence peak would be about 20^h on October 15, or a good 2 hours after sunset and over 10 hours before sunrise, presenting thus the likelihood of a middle-of-the-night exodus.

On October 15 emergence started at $18^h30'$ and increased quickly to a high level lasting from 20^h to $22^h30'$. By the latter time the grass and palmettos were covered with resting adults. Assuming that an exodus of a gradual type would occur, peaking at 03^h, word was sent out for observers to gather and a Kytoon net to be in readiness. This net (Fig. 3) for sampling upper-air strata was as described in Nielsen and Greve (1950) but instead of a sounding balloon a steadier "Kytoon" was used. This device was to be manned by two men and operated downwind from the point of exodus.

No exodus occurred. A few individuals trickled away between 01^h and 04^h which could have been disturbed by the observers. No major activity developed during the morning twilight either. For watching both resting and flying mosquitoes through the night 12-volt spotlights with yellow filters proved very satisfactory. The Kytoon collecting did not, of course, materialize. Older mosquitoes, from a previous brood, were biting badly enough that most observers used repellents. A sample of the new mosquitoes, taken at 01^h, was taken alive and retained several days to establish egg maturation without a blood-meal; 38 percent were autogenous. Sweep net samples of the resting mosquitoes (Table 2) between $01^h35'$ and $05^h30'$ yielded 17 percent to 27 percent females, and these females were from 30 percent to 60 percent mated (by spermathecal examination). Since midday collections the next day at the same site yielded only half as large a female ratio and all of them unmated, it is evident that about half the females collected at night were old females not belonging to the new emergence. The males in these same sweep net collections revealed sexual potencies (hypopygial rotation $\leqq 135°$) increasing from 3 percent at $01^h35'$ to 15 percent at $05^h30'$, indicating that by sunrise ($06^h23'$) less than one male out of five was potent.

Not having left during the night, for unaccountable reasons, the new mosquitoes spent the daytime, October 16, at the emergence site, assuring a twilight exodus which did, of course, occur. Daytime collections gave a truer sex-ratio for the first day's emergence (Table 2): 7–8 per cent females. By $15^h45'$ the mosquitoes were averaging 20 hours of age; the females were still 100 percent virgin, even though by then two-thirds of the males were potent. Late in the afternoon, females coming to probe were collected and examined chromatographically for age;[2] at $16^h30'$ 36 percent were under 24 hours of age but at $18^h00'$ only 3 percent were of this age. This seemed to indicate that even though many of the new females came to a blood source, the great majority of biting females, especially near sunset, were old ones not belonging to the emergence under study. Both young and old coming to bite probably did so only after disturbance had set them flying, however.

In anticipation of the exodus at twilight, J. S. Haeger set out two "sticky nets" of the type he had recently been experimenting with. These were 22-inch round nylon nets covered with adhesive, 20 feet above the ground, one south and the other west of the emergence site. The nylon net averaged 11 hexagonal cells to the linear inch, and the adhesive formula was:

1-1/2 lb. amber gear grease
1 qt. #20 motor oil
1 pt. mineral spirits

By $17^h50'$ all was in readiness for observation of the twilight exodus: sticky nets, Kytoon standing by, spotlights, nets, pill boxes, forceps, etc., etc. Daytime temperatures had averaged 27° C., the relative humidity 60 percent, and the wind out of the west at 5 to 7 miles per hour.

Sunset was at $17^h52'$. During the twilight interval the wind remained from the

[2] Aging by chromatography is being developed as a technique by Dr. P. T. M. Lum. It has not yet been published.

TABLE 2.—Summary of collections during October 1958 *Aedes taeniorhynchus* exodus study at Borrichia Slough. Collection symbols: Sw = sweep net, Asp = aspirator, St = sticky net

		October 16											17	
		Sw 0100	Sw 0135	Sw 0230	Sw 0330	Sw 0430	Sw 0530	Sw 1200	Sw 1545	Asp 1630	Asp 1800	St 1810	Sw 1035	Asp 1630	St 1810
Total	♂		201	239	74	153	114	121	117			282	870		45
	♀		41	49	27	39	24	9	10			73	1023		131
	% ♂		83	83	73	80	83	93	92			79	46		26
Males	Rotation of Hypopygia														
	0°		50	47	12	24	7	4	0			0	32		0
	45°		63	89	16	42	14	5	0			11	172		0
	90°		33	34	13	30	14	81	39			36	358		11
	135°		4	4	1	7	5	25	56			112	40		18
	180°		1	0	0	3	1	1	18			73	4		14
	% mature		3	2	2	9	15	22	65			80	7		75
	Damaged		50	65	32	47	73	5	4			50	264		2
	% damaged		25	27	43	31	64	4	3			18	30		4
Females	Virgin		5	4	7	5	7	9	10			15	80		75
	Mated		5	6	3	5	3	0	0			5	0		51
	% "		50	60	30	50	30	0	0			25	0		41
	> 24 " old									19	29			8	
	< 24 " old									11	1			52	
	% "									36	3			86	
	Ov. advanced	14												4	
	Ov. not "	23												7	
	% autogenous	38												36	

east but increased slightly in velocity, 8–9 miles per hour with gusts up to 18 miles per hour. The temperature fell to 24° C. and leveled off. The relative humidity rose to 90 percent. Barometric pressure was quite stable at 1016 millibars.

Although a few specimens left between 18h00′ and 18h05′ the mass exodus was at 18h06′, or 14 minutes after sunset. The mosquitoes appeared to rise almost straight up, 15 to 20 feet, before being carried away by the northeast wind. Exactly simultaneously, thousands of males began swarming above the tops of every tree, utilizing every branch tip and palm frond. No one observed what could be surely identified as mating in these numerous and large swarms—even with the combination of amber spotlights and binoculars which made examination of the more distant swarms most satisfactory. The virtual eruption of swarms at the precise moment of mass exodus, the ubiquity and large size of the swarms, and the absence of mating—all these were most impressive.

The strong gusts of wind made the Kytoon net collecting impossible, but the sticky nets caught 73 female and 282 male *A. taeniorhynchus* during the short interval ending at 18h30′. Since the resting population at midday was 93 percent and 92 percent male (Table 2) and the sticky-net catch 79 percent, one wonders whether the missing 13 percent may not represent those males which went immediately to swarming, especially since the same happened the next evening (see below). Of the 232 males with determinable hypopygial rotation, 80 percent were complete ($\geq 135°$), the estimated age (by temperature correlation) of all males at exodus time averaging 21 hours. The females caught in these sticky nets were 25 percent mated. Since the resting females were 100 percent virgin at 15h45′ there appears to have been some mating on the exodus—if we assume the nets to have caught only the new females. Of the two nets, the south one picked up 77 percent of the collection and the west one 23 percent. The wind data were inadequate for us to relate these catches to wind direction.

The salient points of these twilight observations were, then: (1) the males were 92 percent of the resting population, by sweep net, and 79 percent of the departing population, by sticky net; (2) the specimens averaged 22 hours of age at sunset and 80 percent of the males were judged able to copulate, i.e. had hypopygial rotations of over 135°; (3) the resting females were 100 percent virgin while those departing, as represented in sticky nets, were 25 percent mated; (4) simultaneously with the mass exodus, 14 minutes after sunset, there was a mass and most impressive formation of male swarms; (5) no mating was observed in these swarms.

Observations the next day, October 17, showed the expected rise in female ratio among the second day's emergence; at 10h30′, sweep-net collections gave a 54 percent female figure (compared to 8 percent the first day). Of the males, 7 percent only had completely rotated hypopygia, indicating clearly that virtually none of the first day's males remained among these. At 16h30′ probing females were collected and 86 percent (52/60) were under 24 hours of age (by chromatography). That so many neonate females should be seeking blood was surprising. A subsample of this collection revealed 36 percent autogeny, a figure close enough to the previous day's to make it quite certain that roughly a third of the brood under observation was autogenous.

The sticky nets had worked so well it was decided to test the technique in a more elaborate manner at the anticipated second twilight exodus. Sticky nets were made 1 × 2 feet and suspended in pairs arranged in a 90° V so that when made sticky on both sides an exposure to each of the four cardinal points resulted for each V (Fig. 4). The nets, 34 of them, were fastened to 1 × 2 foot aluminum wire frames and attached at 10-, 20-, and 30-foot levels on three 30-foot poles and four 20-foot poles. These were set out in the slough in as strategic a manner as possible to intercept the exodus.

The weather during civil twilight was like the day before except for a consider-

able lessening of the wind; it was still northeast but only 2–3 miles per hour. The exodus took place between $18^h05'$ and $18^h15'$. It did not appear to be as rushed as the night previous, and opportunity was afforded to see some mating while the departure went on. The exodus appeared to be mainly toward south and west.

All sticky nets together gathered 176 mosquitoes, the males representing 26 percent compared to the previous night's 79 percent. Again the proportion of males in the exodus was less than in the resting population (26 percent : 46 percent), supporting the probability that many males did not depart. By the hypopygial rotation criterion, 75 percent of departing males were potent, compared with 80 percent the previous night. By the spermathecal criterion, 40 percent of the females were mated, compared to the previous night's 25 percent. On the whole then, this exodus generally resembled that of the first night, the major difference being that the proportion of females was greater and more of them were mated.

The Kytoon net worked well this evening. Sampling from 30 to 200 feet above the ground downwind from the exodus yielded nothing. Between 20 and 50 feet some mosquitoes were caught but were found escaping through the netting as fast as caught. The same could have happened, undetected, at the 30- to 200-foot collecting. Nothing was learned except that the method had definite possibilities for establishing the vertical distribution at exodus. Certain modifications of the net were obviously indicated.

The sticky nets were taken down after the exodus, the operation lasting from $18^h45'$ to $21^h00'$. The nets were labeled and laid between sheets of paper, then rolled into a large bundle and taken to the laboratory. Experimentation showed alcohol best for preserving the mosquitoes after removal from the sticky nets. Although the technique was experimental and the rolled-up catches remained in the bundled condition 2-1/2 days before the mosquitoes were removed from the nets, 96 percent (43/45) of the males were satisfactorily examined for degree of hypopygial rotation while 95 percent (126/132) of the females were satisfactorily examined for presence or absence of sperm in the spermathecae.

The potential of this sticky net method of studying migratory departures is evident from the detailed study made in this instance but not here recorded, involving such things as height and direction of flight as differing with sexes, mated state, age, etc., etc. This information is summarized here as follows: (1) the upper nets and downwind traps caught more mosquitoes than the lower and the upwind, this pattern being more pronounced in males than in females. (2) There was some circumstantial evidence that the lower and the upwind nets caught a considerable percentage of older females flying appetentially. (3) There was some evidence that swarming males got caught in the uppermost nets.

This experiment at the Borrichia Slough was therefore successful in demonstrating what can be learned about a migratory exodus of mosquitoes without marking. A three-pronged attack appears indicated: (1) *Observation,* to be concerned especially with the time sequence of the brood's development, i.e., the rhythm of pupation and emergence, the twilight flight behavior, etc., and with the simultaneous gathering of weather data. (2) *Collecting,* to be done on a strategic rather than routine schedule, and utilizing especially the sticky nets, flying nets (*cf.* Ft. Pierce experiment, above), Kytoon nets, rotor nets, sweep nets, and others as indicated. (3) *Laboratory determinations,* as exhaustively as possible to establish sex, age and physiological state of all recovered mosquitoes, with resort to spermathecal and ovarian examination of females, including testing for autogeny, to hypopygial examination of males for age determination, and to chromatography or any other aging technique regardless of sex.

C. Summary

Field techniques for the study of a mosquito migratory exodus are described.

FIG. 4.—The directional sticky nets as used in the Vero Beach 1958 mosquito exodus study.

The production and marking of mosquitoes in large numbers is described. The possibilities of various collecting devices for use at exodus time are discussed and exemplified. The use of methods to determine age and physiological state of field-caught mosquitoes is discussed and exemplified also. Several migratory exodi are described.

D. REFERENCES

CLARKE, J. LYELL. 1937. New and significant experiences in mosquito control in the Desplaines Valley Mosquito Abatement District. Proc. 24th Ann. Meeting of the N. J. Mosq. Exterm. Assoc., pp. 112–126.

HAEGER, J. S. 1960. Behavior preceding migration in the salt-marsh mosquito, *Aedes taeniorhynchus*. Mosq. News 20(2):136–147.

NIELSEN, E. T. 1958. The initial stage of migration in salt-marsh mosquitoes. Bull. Ent. Res. 49(2):305–313.

———. 1960. A note on stationary nets. Ecology 41(2):375–376.

——— and EVANS, D. G. (M.S.) Duration of the pupal stage of *Aedes taeniorhynchus* with a discussion of the velocity of development as a function of temperature.

——— and GREVE, H. 1950. Studies on the swarming habits of mosquitoes and other Nematocera. Bull. Ent. Res. 41(2):227–258.

——— and HAEGER, J. S. 1960. Mating and swarming in mosquitoes. Misc. Publ. Ent. Soc. Amer. (In press).

——— and NIELSEN, A. T. 1953. Field observations on the habits of *Aedes taeniorhynchus*. Ecology 34:141–156.

PROVOST, M. W. 1952. The dispersal of *Aedes taeniorhynchus*. I. Preliminary studies. Mosq. News 12(3):174–190.

———. 1953. Motives behind mosquito flights. Mosq. News 13(2):106–109.

———. 1957. The dispersal of *Aedes taeniorhynchus*. II. The second experiment. Mosq. News 17(4):233–247.

OBSERVATIONS ON THE BREEDING HABITATS OF SOME *CULICOIDES* AND OTHER HELEIDAE IN THE PANAMA CANAL ZONE (DIPTERA)

SAMUEL G. BREELAND
Health Bureau, Canal Zone Government

In connection with biological studies on the salt marsh sand fly, *Culicoides furens* (Poey), in the Panama Canal Zone, a number of observations have been made on the breeding habitats of this and other species of *Culicoides* as well as members of several other genera of Heleidae. As pointed out by Forattini *et al.* (1957), and Wirth and Blanton (1959), there has been little work of this nature reported for the neotropical region. The only references known to the author which apply specifically to the Canal Zone are those of Carpenter (1951) and Woke (1954). In addition, Wirth and Blanton (1959) summarize in table form the known breeding places of Panama *Culicoides* as compiled from existing literature. It is the purpose of this paper to report observations on the breeding habitats of 14 species of Canal Zone *Culicoides*, 10 of which are additions to the list of species with recorded breeding habitats (*alahialinus, barbosai, debilipalpis* gr., *gorgasi, diabolicus, guyanensis, insignis, leopoldoi, paraensis,* and *wokei*), 2 which offer additional habitat knowledge (*hoffmani* and *reticulatus*), and 2 which corroborate existing knowledge (*furens* and *trinidadensis*). In addition, observations are given on the breeding places of representatives of 7 genera of heleids. Three of the heleid genera are represented by known species (*Forcipomyia raleighi* Macfie, *Helea fuscivenosa* (Lutz), and *Stil-*

obezzia antennalis (Coq.) and *S. coquilletti* K.), while the other 4 are represented by one or more unidentified species (*Atrichopogon, Bezzia, Dasyhelea,* and *Johannsenomyia*).

The data presented are, for the most part, based on 351 positive weekly emergence cage collections from 774 cage-weeks of operation in 144 different locations representing 8 habitats. The data were collected between July, 1958, and September, 1959. With few exceptions, observations were made on the Atlantic side of the isthmus on the east side of the Panama Canal in and near the mangrove swamps within close proximity to community housing areas.

METHODS

Emergence cages, modified from those of Dove *et al.* (1932) were utilized. These cages of two types, metal and wood, covered surface areas of 452 square inches and 484 square inches, respectively. The yield of the two types of cages was not significantly different in any of the habitats when tested side by side. The metal cages were made by transversely cutting 55 gallon shortening drums in half with an acetylene torch and welding a fruit jar cap, lip out, to the side of the container a few inches below the solid end. The area encompassed by the cap was previously cut with the torch. Two cages were constructed from a single drum. The wooden cages were made from discarded ammunition boxes by covering with tar paper and stripping heavy gauge sheet metal around the open end to facilitate implanting the cage. The jar cap was countersunk in a hole made with a keyhole saw. These cages were in position for varying lengths of time, the average being 6.8 weeks per location. Each Monday morning, the positively phototactic insects were removed from the collecting jars into vials of 70 percent alcohol. The heleids were subsequently identified and recorded. The cages were moved to new locations when it was believed the area had been adequately sampled. Unless otherwise noted, all data in this study are from this source. Ecological observations including measurements of salinity, soil temperatures, and pH were recorded from each type habitat studied; however, efforts to correlate the latter two environmental factors with breeding, either quantitatively or qualitatively, were fruitless, and results are not included in this study. Salinity of the water in each habitat was determined by means of a set of hydrometers.

OBSERVATIONS ON BREEDING HABITATS

The coastal areas at each entrance to the Panama Canal support extensive growths of mangrove swamp with associated tidal marshes. Since the majority of Canal Zone residents live near the coast, it is necessary in mosquito control activities that these areas be drained by a vast network of tidal ditches to reduce impounded rain waters. *Culicoides,* being semi-aquatic in the larval stages, are able to thrive in these moist, tide-bathed swamps, which, in spite of superficial similarity, exhibit a range of habitats which differ in their suitability for *Culicoides* breeding. Since control efforts are costly, it is desirable to know the preferred and tolerated habitats of a given species. The writer has classified breeding habitats into eight principal types, as follows.

Type 1. Black muck mangrove swamp, non-inundated.—Areas well removed from the ocean shore line with tidal ditches for drainage. Soil of the black muck type, rich in animal and vegetable matter, matted together with fine roots. Usually saturated with salt water, the source of which is seepage and spillage from ditches with the incoming high tides. Sometimes supersaturated (oozing to the step) in low areas and near ditches after highest tides; occasionally temporarily inundated at time of high tides coupled with heavy rains. Conspicuous vegetation completely dominated by mangrove trees (*Rhizophoro mangle* L.). Salinity, varying with amount of rainfall, ranges between 5.4 and 26.4 parts per thousand.

Type 2. Black muck mangrove swamp, inundated.—Areas near the ocean shore-

line, usually ditchless, exposed to frequent inundation by high tide water. Swamp floor of black muck soil as in type 1, above. When not actually inundated by sea water, the soil is saturated. Foliage more sparse than in type 1 habitat and soil temperatures a little higher.

Type 3. Coral sand mangrove swamp, non-inundated.—Areas near the ocean shore line which were at one time exposed to high tide inundation and were type 4 habitats, but which have been isolated from direct inundation by man-made obstructions, in most cases road banks. Sufficiently close to the ocean so that seepage, rather than inundation, is the source of the salt water environment. Usually not so well drained, resulting in more of a rain-tide mixture. Salinity, 16.5 to 31.5 parts per thousand.

Type 4. Coral sand mangrove, inundated.—Ditchless areas near the ocean shore line exposed to frequent inundation by high tide water. The soil more of a mixture of black muck and coral sand, the latter forming the top one-half inch or so of the swamp floor. Soil smooth with a lack of matted roots, less decaying matter than in black muck type. Inundating water is sea water.

Type 5. Mangrove tide ditch muck.—(A dry weather condition.) Many areas well removed from high tide inundation, receive sea water only in and near the drainage ditches as a result of high tide flow in the ditch channels. Thus, in dry weather, there is created a super-saturated oozing muck in the sides and bottoms of these ditches, fully exposed to the sun with little or no vegetation except algae. The soil temperatures are usually in the nineties, and the salt content is from 26.5 to 31.5 parts per thousand.

Type 6. Salt marsh.—Unshaded areas of low elevation characterized by a covering of grasses and sedges. Not much breeding except in and near drainage ditches traversing the area. The soil in these ditches is a grey or brown muck, saturated to super-saturated, exposed to sun and light. The salinity is from 15 to 26.5 parts per thousand.

Type 7. Fresh water mangrove swamp.—Areas adjacent to rivers or fresh water streams flowing through mangrove swamp or salt marsh. Tidal drainage ditches empty into these streams which carry the drainage water out to sea with the descending tide. For the most of their length these streams have insufficient effect to change the typical mangrove environment; however, certain topographic peculiarities may result in a predominantly fresh water habitat near these streams within the confines of an otherwise saline area. Except for salinity, the habitat is very similar to the salt water types, 1 through 5.

Type 8. Adjacent forests.—Forest areas adjacent to mangrove swamps. Characteristic vegetation includes the star apple (*Chrysophyllum*), wild fig (*Ficus*), almendro (*Dipteryx panamaensis*), maragua (*Poulsenia armata*), and many palms, aroids, heliconias, and lianas (Wirth and Blanton, 1959). Soil, at least in places, sufficiently moist for *Culicoides* breeding, usually saturated to inundated in rainy season, high in organic matter. A fresh water habitat.

Ecological Observations

The distribution of the various species according to the type habitat in which they were found is given in Table 1. The relative reliability of a habitat association with a given species may be ascertained by the number of times the species was found in a particular habitat, the number being given in the table.

In a number of instances, two or more species were collected from the same cage at the same time, thereby establishing a tolerance for the same larval habitat. The associations so observed are listed under the discussions of the species, which follow:

Culicoides alahialinus Barbosa.—Collected 1 female from a cage placed on bank of Puerto Escondido River (type 7 habitat)

at margin of well-drained mangrove swamp, December 5, 1958. The soil was saturated from river seepage and rainfall. The adult was associated with *C. leopoldoi* and *Stilobezzia* sp.

Culicoides barbosai Wirth and Blanton.—Collected 74 specimens (32 males, 42 females) from 20 collections in 11 locations representing 5 salt habitats. Recovered from cages during each calendar month except May and July, but its presence in biting records during these months completes the year-round distribution. This species, while well distributed in coastal mangrove areas, seems to show preference for coral sand habitats (types 3 and 4) near the ocean shore line. Found in cage jars with *C. furens, Dasyhelea* sp., *Stilobezzia antennalis,* and *S. coquilletti;* reared from muck samples with *C. trinidadensis.*

Culicoides debilipalpis gr.—Collected 3 adult males from saturated, black muck mangrove in Galeta swamp, August 3, 1959, and another male from the same

TABLE 1.—Distribution of the Heleid species recovered from emergence cages in different habitat types

Species	Number of times collected	Number of different cage locations	Number of times collected species from each habitat type: Black muck mangrove, non-inundated by tide 1	Black muck mangrove, inundated by tide 2	Coral sand mangrove, non-inundated by tide 3	Coral sand mangrove, inundated by tide 4	Mangrove tide ditch muck 5	Salt marsh 6	Fresh water mangrove 7	Forest areas adjacent to mangrove 8
Culicoides										
alahialinus	1	1	—	—	—	—	—	—	1	—
barbosai	20	11	4	3	6	6	1	—	—	—
debilipalpis gr.	2	2	2	—	—	—	—	—	—	—
diabolicus	4	4	2	—	—	1	—	—	1	—
furens	239	66	184	13	29	4	2	7	—	—
gorgasi	3	3	3	—	—	—	—	—	—	—
guyanensis	1	1	1	—	—	—	—	—	—	—
hoffmani	4	1	4	—	—	—	—	—	—	—
insignis	2	2	—	—	—	—	—	—	—	2
leopoldoi	12	5	—	—	—	—	—	—	11	1
paraensis	1	1	—	—	—	—	—	—	—	1
reticulatus	5	2	—	—	—	1†	—	—	—	4
trinidadensis	1	1	—	—	—	1	—	—	—	—
wokei	2	2	—	—	2	—	—	—	—	—
Atrichopogon sp.	3	3	2	1	—	—	—	—	—	—
Bezzia sp.	1	1	—	—	—	—	—	—	1	—
Dasyhelea sp.	27	19	20	2	—	—	5	—	—	—
Forcipomyia										
raleighi	3	2	—	—	—	—	—	—	3	—
sp.	5	4	4	—	—	—	1	—	—	—
Helea fuscivenosa	3	2	3	—	—	—	—	—	—	—
Johannsenomyia sp.	2	2	—	—	—	—	—	—	—	2‡
Stilobezzia										
antennalis	3	3	1	—	—	—	—	—	—	2
coquilletti	3	3	1	—	—	—	—	—	—	2
sp.	4	3	1	—	—	—	—	—	3	—

* Reared from tree-hole collected larvae.
† A crab hole was under the cage from which this collection was made.
‡ Margin of fresh water stream.

type habitat (type 1), but from a different location, September 14, 1959. Found in association with *C. furens*.

Culicoides diabolicus Hoffman.—This species is the most numerous in light trap collections, but its preferred breeding habitat has escaped detection. Five specimens (4 males, 1 female) were recovered from 3 habitats. The species was found in mangrove swamp (habitat types 1 and 4) and in a fresh water mangrove situation, along the bank of the Puerto Escondido River (type 7 habitat). The species was recovered during October, November, and December, 1958. Found associated with *C. furens* in the salt mangrove, and with *C. leopoldoi* and *C. insignis* in the fresh water situation.

Culicoides furens (Poey).—Collected hundreds of specimens from 239 cage collections representing 66 locations and all six of the salt water habitats. No specimens were recovered from fresh water habitats 7 and 8; however, many collections were made in areas of rather low (1.5 to 5.8 parts/1000) salt content. Widely distributed throughout the mucky salt water bathed coastal areas, year round. Reaches greatest abundance in mangrove swamp or marsh only partially shaded. Densest populations found in super-saturated muck of tide ditches with no standing water and partially or fully exposed to sunlight. Virtually absent in densely shaded mangrove. Collected in association with *C. barbosai, C. debilipalpis* gr., *C. diabolicus, C. gorgasi, C. guyanensis, C. trinidadensis, C. wokei, Dasyhelea* sp., *Atrichopogon* sp., *Forcipomyia* sp., and *Helea fuscivenosa*.

Culicoides gorgasi Wirth and Blanton.—Collected 3 females from 3 locations in a single habitat (type 1, black muck mangrove). Two specimens were taken in February from Galeta swamp cages, and 1 specimen in May from a Fort Randolph cage. Associated with *C. furens* and *Dasyhelea* sp.

Culicoides guyanensis Floch and Abonnenc.—Recovered 2 male specimens from a Galeta swamp cage, type 1 habitat (black muck mangrove) on April 20, 1959, along with 30 specimens of *C. furens*. This is the same cage, in the same location, from which a single specimen of *C. gorgasi* was taken on February 23, 1959.

Culicoides hoffmani Fox.—Five specimens (2 males, 3 females) recovered from a single location in black muck mangrove habitat (type 1) with from 1 to 2 inches of standing water. Cage operated in position for a period of 6 cage-weeks, October 21, 1958–December 5, 1958, near Rainbow City. *C. hoffmani* was recovered in this location to the exclusion of other species, although a subsequent study revealed no special habitat characteristics, except for standing water. Specimens of *C. furens* were recovered from a nearby cage in the same habitat. This species was reported from tree hole debris by Fox (1949).

Culicoides insignis Lutz.—Only 2 specimens of this species were recovered from emergence cages; a female from a rain saturated forest floor near Coco Solo Hospital, December 15, 1958, in association with *C. leopoldoi* and *C. diabolicus,* and a male from stagnant water over a manhole cover at Coco Solo Hospital on August 17, 1959. This species is reported by Wirth and Blanton (1959) as being abundant in the arid tropics cow pasture country, a condition which does not exist on the Atlantic side.

Culicoides leopoldoi Ortiz.—Collected 45 specimens (18 males, 27 females) from 12 collections in 5 locations, representing 2 fresh water habitats (types 7 and 8). This species was recovered frequently from cages along the bank of the Puerto Escondido River, a fresh water mangrove situation, during November, December, and January. Two males were taken from a cage in a saturated forest area near France Field on December 8, 1958. Collected in association with *C. diabolicus, C. alahialinus, C. insignis, Bezzia* sp., and *Stilobezzia* sp.

Culicoides paraensis (Goeldi).—One male emerged on September 8, 1958, from tree hole debris collected September 5, 1958.

Culicoides reticulatus Lutz.—Recovered 41 specimens (32 males, 9 females) from 5 collections in 2 locations representing 2

habitats. Four collections were from a saturated forest floor (type 8 habitat), and one collection, yielding a single specimen was from a type 4 (inundated coral sand mangrove) habitat, but this cage was placed over a crab hole which might have been the source of the specimen. This species has been previously reported from crab holes by Lutz (1913) and by Forattini (1957). Indications are that this is predominately a forest floor species in well saturated areas during wet weather. Collected July, August, and September, 1959. No associated species.

Culicoides trinidadensis Hoffman.—Two females emerged August 10, 1959, from soil samples taken from a type 4 habitat (non-inundated coral sand mangrove), July 27, 1959, on Largo Remo Island. Galeta Point light trap where large numbers of this species are taken is in close proximity. In association with *C. furens* and *C. barbosai*.

Culicoides wokei Fox.—Recovered 7 specimens (3 males, 4 females) from a coral sand mangrove habitat in Galeta swamp, October 13, 1958, and 11 specimens (5 males, 6 females) from the same type habitat (type 3) on Pina Guapa Island, off Galeta Point, August 17, 1959. In association with *C. furens*.

Atrichopogon sp.—Collected 7 specimens (5 males, 2 females) from 3 locations representing 2 mangrove swamp habitats. One male emerged along bank of tidal ditch in non-inundated mangrove (type 1), Coco Solo Swamp, February 9, 1959, and 2 females in a like habitat in Galeta swamp, March 9, 1959. Recovered 4 males from a cage in type 2 habitat (black muck mangrove, inundated) on August 4, 1958, in association with *C furens,* and *Dasyhelea* sp.

Bezzia sp.—Recovered 1 male specimen from the bank of Puerto Escondido River (type 7 habitat) November 28, 1958. In association with *C. leopoldoi*.

Dasyhelea sp.—Collected numerous specimens of several species from a variety of habitats. Well distributed in mangrove areas and quite often (18 of 27 collections) associated with *C. furens*. Reaches greatest abundance in super-saturated ditch muck and similar areas of swamp which are exposed to the sun and with little or no visible vegetation. Woke (1954) gives a more complete account of *Dasyhelea* breeding in the Canal Zone. In addition to *C. furens,* representatives of this genus were found in association with *C. barbosai, C. gorgasi, Atrichopogon* sp., and *Forcipomyia* sp. Woke (1954) reports the recovery of *Dasyhelea* larvae July through September. The writer has emergence cage records for each month except April, May, and June, normally the last three months of dry season.

Forcipomyia sp.—A total of 12 specimens (7 males, 5 females) was recovered from 4 collections in type 1 mangrove in 3 different swamps, Galeta, Coco Solo, and Margarita, in February, September, and December, respectively. Associated with *C. furens* in the Galeta collection. In February, 1959, numerous specimens were taken in association with a dense population of *Dasyhelea* in a single collection from the oozing muck of a tide ditch, open to the sun (type 5 habitat). Also present in this collection were *Stilobezzia antennalis* and *S. coquilletti*.

Forcipomyia raleighi McFie.—Collected a single female from the bank of Puerto Escondido River, January 6, 1959, with no associated heleids. Collected 6 males and 6 females from an emergence cage in fresh water pocket of mangrove swamp, January 6, 1959, and an additional male and 2 females, January 19, 1959. In each case, considerable decaying leaves were covered by the cage, ground moist, but not mucky.

Helea fuscivenosa (Lutz).—Collected a total of 7 specimens (4 males, 3 females) from 2 locations from a single (type 1) habitat. One female emerged along with several specimens of *C. furens,* from a cage near France Field, August 18, 1958. Three males, along with several specimens of *C. furens,* emerged from a Galeta mangrove swamp, August 9, 1959, followed by the recovery of 1 male and 2 females from the same cage, September 15, 1959.

Johannsenomyia sp.—Collected several specimens from two separate cages along

the margin of a narrow and shallow portion of the Majagual River near France Field, March 9, 1959. In association with *Stilobezzia antennalis,* and *S. coquilletti.* Area exposed to the sun.

Stilobezzia antennalis (Coq.) and *S. coquilletti* K.—These 2 species were found in relatively large numbers on the margin of shallow portion of the Majagual River near France Field, March 9, 1959. In association with each other and with a species of *Johannsenomyia,* and with *C. barbosai.* Woke (1954) reported *S. coquilletti* reared from larvae taken from algae and black muck from a shallow stream of fresh water flowing through tidal marsh, a situation not unlike that reported here. Also collected in association with *Forcipomyia* sp. in a collection from mangrove swamp near Rainbow City.

Stilobezzia sp.—Several specimens each, of two species, collected in association with *C. leopoldoi,* November 24, 1958, from bank of Puerto Escondido River (type 7 habitat). The same 2 unidentified species were collected from a different cage in the same habitat on December 5, and again on December 15, 1959. In association with *C. alahialinus* in the December 5, collection.

Summary

Observations on the breeding places of 14 species of *Culicoides* and representatives of 7 other genera of Heleidae are recorded. Results are based on collections made between July, 1958, and September, 1959, in and near coastal mangrove areas of the Panama Canal Zone. In addition to habitat descriptions and listings, the larval associations and dates of occurrence are given for each species.

Acknowledgment

I wish to express my sincere thanks to Dr. W. W. Wirth of the U. S. National Museum for the identifications and verifications of the heleid species discussed in this paper.

References

Carpenter, S. J. 1951. Studies of *Culicoides* in the Panama Canal Zone (Diptera, Heleidae). Mosquito News 11(4):202–208.

Dove, W. E., Hall, D. G., and Hull, J. B. 1932. The salt marsh sandfly problem. Ann. Ent. Soc. Amer. 25:505–522.

Forattini, O. P., Rabello, E. X., and Pattoli, D. 1957. A brief note on breeding places of *Culicoides* in São Vicente, Brazil. Mosquito News 17(4):312–313.

Fox, I. 1949. Notes on Puerto Rican biting midges or *Culicoides* (Diptera: Ceratopogonidae). Bull. Brooklyn Ent. Soc. 44:29–34.

Lutz, A. 1913. Contribuição para o estude das "Ceratopogoninas" hematofagus do Brasil (parte sistemática). Mem. Inst. Oswaldo Cruz. 5:45–73.

Wirth, W. W., and Blanton, F. S. 1959. Biting midges of the genus *Culicoides* from Panama (Diptera: Heleidae). Proc. U. S. Natl. Mus. 109: 237–482.

Woke, P. A. 1954. Observations on Central American biting midges (Diptera, Heleidae). Ann. Ent. Soc. Amer. 47(1):61–74.

MOSQUITO LARVICIDE FIELD TESTS IN IRRIGATED PASTURES OF THE SAN JOAQUIN VALLEY, CALIFORNIA

LAWRENCE L. LEWALLEN [1] AND C. M. GJULLIN [2, 3]

Chemical control of mosquito larvae in California depends primarily on the application of chlorinated hydrocarbons and organophosphorus compounds. Materials currently in use have limitations which justify a continuing search for more effective chemicals.

The chlorinated hydrocarbons may present residue problems when used to control mosquito larvae in areas where feed and forage crops are produced. The organophosphorus compound, parathion, is a highly efficient and economical chemical control agent, but unfortunately has an extremely high mammalian toxicity which presents an element of danger in handling. Malathion, another organophosphorus compound, is considerably safer to handle but is less effective and more expensive.

Some of the objectives that are sought in a mosquito larvicide screening program are: (1) high toxicity to mosquito larvae; (2) low vertebrate toxicity; (3) economical application. Materials that meet all of these criteria are difficult to find.

Recent work with new materials has indicated that several offer promise as mosquito larvicides. Although some of these compounds will undoubtedly be found not to have performed outstandingly at all, it seems appropriate to report on the activity of all materials which were field tested during 1959.

The procedures observed in conducting these tests were the same as outlined by Lewallen (1958) except that 1/32 acre plots were used, and the emulsion concentrates were mixed with 1/2 gallon of water for the spray application.

Results of field tests conducted in 1959 are given in Table 1.

Bayer 29493 (*O,O*-dimethyl 4-methylthio-*m*-tolyl ester of phosphorothioic acid) was the most outstanding material tested. The mammalian toxicity is fairly low which makes this compound of interest as a mosquito larvicide. The acute oral LD-50 to rats is approximately 310 mg./kg. Other compounds of interest include: methyl parathion, methyl trithion, barthrin, Geigy 30494, and Shell SD4402. The bacterial insecticide, Thuricide, did not perform well as a mosquito larvicide.

The development of parathion-resistance in *Aedes nigromaculis* (Ludlow) (Lewallen and Nicholson, 1959) has prompted a search for an effective material that can be substituted at a reasonable price. The results of some of the materials investigated are reported in Table 2.

It appears that either Metacide or methyl parathion at 0.1 lb./acre would be an effective substitute for ethyl parathion where resistance poses a problem in control. Cost of treatment with these compounds runs only a couple of cents more per acre than with ethyl parathion. Based on previous tests, the data in Table 2 would seem to

[1] California State Department of Public Health, Bureau of Vector Control, Fresno.

[2] Entomology Research Division, Agricultural Research Service, U. S. Department of Agriculture, Corvallis, Oregon.

[3] The authors acknowledge the cooperation of J. H. Brawley, Kings Mosquito Abatement District, in providing field plots for these studies. Agencies supplying materials for these tests were: Methyl Parathion, Monsanto Chemical Co., St. Louis, Mo.; Metacide, Moyer Chemical Co., San Jose, Calif.; Methyl Trithion, Stauffer Chemical Co., Mountain View, Calif.; Bayer 29493, Farbenfabriken Bayer, Vero Beach, Fla.; Barthrin, McLaughlin-Gormley-King Co., Minneapolis, Minn.; G 30494, Geigy Chemical Corp., Yonkers, N. Y.; SD 4402, Shell Development Laboratories, Modesto, Calif.; Thuricide, Bioferm Corp., Wasco, Calif.; Guthion, Chemagro Corp., Kansas City, Mo.; Malathion, American Cyanamid Co., Stamford, Conn.; E.P.N., E. I. duPont de Nemours and Co., Wilmington, Del.

TABLE 1.—Tests with mosquito larvicides in irrigated pastures against 4th instar larvae [a]

Compound and formulations	Rate of application lb./acre	24-hour percent mortality	
		Aedes nigromaculis	*Culex tarsalis*
Methyl parathion	0.1	100.0	100.0
2 lb./gal. E.C.	0.05	99.9	97.0
	0.025	99.0	——
Methyl Trithion	0.2	99.6	——
4 lb./gal. E.C.	0.1	98.0	99.6
	0.05	84.6	87.5
Bayer 29493	0.05	100.0	100.0
50% E.C.	0.025	99.2	100.0
	0.0125	——	84.0
Barthrin	0.25	100.0	100.0
25% Tech; 70% xylene;	0.2	98.5	97.0
5% Triton X-100	0.1	95.8	94.5
Geigy 30494	0.2	100.0	100.0
2 lb./gal. E.C.	0.1	99.6	98.0
	0.05	90.0	——
Shell SD4402	0.25	100.0	100.0
1.25 lb./gal. E.C.	0.2	95.7	——
	0.1	95.0	93.0
Thuricide	2.0	54	——
3×10^9 Viable Spores	1.0	41	——
Per Gram W.P.	0.5	77 [b]	——
(*Bacillus thuringiensis*)			

[a] Each test replicated 3 to 5 times.
[b] One test only.

indicate that malathion application rates could be reduced considerably by combination with Shell SD4402. Also less SD4402 is required to produce an effective kill than when used alone. This would appear to indicate a synergistic effect when these materials are combined. If the new material is not too costly, a combination of these two materials might be used effectively. Residue restrictions that pertain to chlorinated hydrocarbons must be observed with the mixture.

Emulsion concentrate formulations of EPN, although effective, are somewhat doubtful as to availability. The cost of Guthion emulsion concentrate remains high.

SUMMARY

During 1959, seven materials were extensively tested against fourth instar larvae of *Aedes nigromaculis* (Ludlow) and *Culex tarsalis* Coquillett in irrigated pastures. The most outstanding material tested was Bayer 29493 (*O,O*-dimethyl 4-methylthio-*m*-tolyl ester of phosphorothioic acid). Concentrations as low as 0.05 lb./acre gave complete mortality of both species. The mammalian toxicity of this compound is fairly low.

Other compounds that are of interest as mosquito larvicides include: methyl parathion, methyl trithion, barthrin, Geigy 30494, and Shell SD4402.

The bacterial insecticide, Thuricide, did not perform well as a mosquito larvicide.

Tests against parathion-resistant *Aedes nigromaculis* larvae have indicated that either methyl parathion or Metacide (80 percent methyl parathion, 15 percent ethyl parathion) at 0.1 lb./acre can be used economically in controlling resistant larvae.

TABLE 2.—Field tests against parathion-resistant 4th instar *Aedes nigromaculis*

Compound and formulations [a]	Rate of application lb./acre	24-hour percent mortality [b]
Metacide		
60% methyl parathion	0.1	100.0
15% ethyl parathion	0.05	98.0
7.5 lb./gal.	0.025	94.0
Methyl parathion	0.1	100.0
2 lb./gal.	0.05	99.9
	0.025	99.0
Malathion 5 lb./gal.	0.25 Mala. + 0.05 SD4402	100.0
Shell SD4402		
1.25 lb./gal.	0.1 " + 0.05 "	99.0
EPN	0.1	100.0
4 lb./gal.	0.05	95.3
Guthion	0.5	100.0
1.5 lb./gal.	0.3	89.0
Parathion	0.1	97.0
2 lb./gal. (control)		

[a] Emulsion concentrates.
[b] Average of 3 to 5 replications.

The cost of treatment with these compounds runs only a couple of cents more per acre than with ethyl parathion.

Tests with combinations of malathion and Shell SD4402 indicate that dosages of each compound can be reduced considerably by combination rather than when used alone. This would indicate that a synergistic effect may be exerted when these compounds are combined. Residue restrictions that pertain to chlorinated hydrocarbons must be observed with the mixture.

Literature Cited

LEWALLEN, L. L. 1958. Larviciding tests against mosquitoes in irrigated pastures of the San Joaquin Valley, California. Proc. Calif. Mosq. Contr. Assoc., 26:88–90.

LEWALLEN, L. L. and NICHOLSON, L. M. 1959. Parathion-resistant *Aedes nigromaculis* in California. Mosquito News 19(1):12–14.

UTAH MOSQUITO ABATEMENT ASSOCIATION

Sixty per cent of the people in the state of Utah are now living within the boundaries of organized mosquito abatement districts.

President	*Vice-President*	*Sec.-Treas.*
KARL L. JOSEPHSON	MORRIS F. SWAPP	GLEN C. COLLETT
Box Elder Co. M.A.D.	Davis Co. M.A.D.	Salt Lake City M.A.D.
Brigham City, Utah	Bountiful, Utah	401 City-County Bldg.
		Salt Lake City, Utah

Proceedings of Annual Meetings for Sale.

OBSERVATIONS ON THE BIOLOGY OF *EUCORETHRA UNDERWOODI* UNDERWOOD IN PASSAIC COUNTY, NEW JERSEY AND BRISTOL COUNTY, MASSACHUSETTS

ROBERT W. LAKE [1]

Eucorethra underwoodi is the largest member of the Chaoborinae found in the Nearctic Region. It was first collected by Needham (Felt 1904) from a cold spring at Saranac Inn in New York State in June 1900.

The author first collected the large predacious larvae of this species in Passaic County, New Jersey on December 3, 1954 and has since had an opportunity to observe the larvae and pupae on many occasions. More than 60 visits have been made to the breeding sites from December 3, 1954 to April 9, 1959 to observe and collect larvae and pupae, record temperature and to note any pertinent facts pertaining to the life history of the species. Observations in Bristol County, Massachusetts have been limited to a few months in 1959.

The author was especially interested in this species not only because of its unusual size, appearance and habits but also because little about its biology has appeared in the literature.

Distribution

United States—Widely distributed over northern United States and Canada.

New Jersey—Passaic County: West Milford Township, Clinton Reservoir area and Bearfort Mountain north of Warwick Turnpike.

Massachusetts—Barnstable County: Yarmouth; Berkshire County: Savoy; Bristol County: Westport, North Dartmouth, Norton; Middlesex County: Framingham; Plymouth County: West Bridgewater.

[1] Formerly Assistant Superintendent, Passaic County Mosquito Extermination Commission, Paterson, New Jersey. Presently Superintendent, Bristol County Mosquito Control Project, North Dighton, Massachusetts.

Breeding Sites

In Passaic County, New Jersey, larvae were found at the upper edge of a sphagnum bog beneath the roots of hemlocks (*Tsuga canadensis*) and rhododendron (*R. maximum*). (Fig. 1). Larvae were seldom found far from the protection of holes formed by these roots. This area was always well shaded because of the dense cover of hemlock and rhododendron but the holes where *Eucorethra* were found seldom were frozen solid except in extremely cold periods.

Larvae from Bristol County, Massachusetts were collected in the following habitats: under tree roots in the vicinity of slow-moving streams, under uprooted trees near streams or ponds and woodland swamp areas.

Other breeding sites mentioned in the literature include springs, dark permanent forest pools, cold mountain pools, streams and rain water barrels.

Temperature data recorded from the New Jersey breeding sites when larvae or pupae were present and the surface was not frozen varied from 37° F to 55° F.

Life Cycle

Egg: Eggs of this species have never been collected by the author but it is fairly safe to assume that they are laid in the debris of the breeding site, rather than on the water surface, since water in these areas dries up shortly after the adults emerge in May and June and reflooding does not usually take place until fall.

Larva: Larvae occurred after fall rains which caused the breeding sites to reflood. At no time were first instar larvae found before September 30, although flooding

occurred at the breeding sites as early as July 29 in 1958 and August 23 in 1956.

Earliest dates of appearance for respective years are as follows:

1955—October 20
1956—November 5
1957—November 7
1958—September 30

Water temperatures when first appearance was noted, varied from 47.5°–54° F.

Larval appearance continued into December as additional rains raised the water level. This apparently was due to the fact that some eggs were laid at a higher level than others within the breeding site. Because of the uneven hatching thus produced, it was difficult to compile any data on the length of time spent in the various instars. Larval collection data show that first instar larvae were found from September to December, second instar from October to February, third instar from October to April and fourth instar from October to May. This monthly distribution data, of course, is entirely dependent on the date and extent of precipitation in the late summer and fall and would vary considerably in various parts of its range in North America.

Larvae are generally found resting at the water surface and parallel to it. As the water in the breeding holes becomes colder the larvae tend to remain on the bottom. Ice cover was usually present for short periods on some or all of the areas, at which time the larvae are apparently able to obtain oxygen from the water.

Some cannibalism undoubtedly occurs in the limits of the small breeding holes as cannibalism has been noted by the author in the laboratory and by Underwood (1903) who observed it among specimens of this species when the temperature

FIG. 1.—One of the *Eucorethra underwoodi* breeding sites, under hemlock roots, in Passaic County, New Jersey.

of the water began to rise. Felt (1904) also noted, that in the absence of more suitable food they attacked each other.

In most instances the larvae were observed to avoid light, usually seeking the darkest corner of a breeding site. When a flashlight is shone upon them they wiggle vigorously on the surface but do not descend to the bottom.

The author found that frequently when the breeding site was dipped for any length of time the larvae tended to return to the surface rather than remain hidden in the bottom debris.

When collecting under ice and when the water was very cold the debris had to be pretty thoroughly stirred up to find larvae.

Mature larvae may attain a size of 12–16 mm. and range in color from light brown to dark brown or black.

Pupa: The large pupae are very similar in gross appearance to *Aedes* and *Culex* pupae.

Earliest collecting date for pupae in Passaic County, New Jersey was on May 13, 1957. During 1956 pupae were first found on May 14 and in 1959 on May 23.

Temperature of the water when pupae were present ranged from 47.5–51° F.

Adult: Although no adults were seen or collected at the breeding site, evidence of pupal skins and disappearance of pupae establish the fact that the adults emerge in late May and early June in Passaic County, New Jersey. The only adults observed, emerged from field collected pupae.

Larval Feeding: Associated Mosquitoes and Invertebrates Which Might Serve as a Source of Food

In many of the *E. underwoodi* collections made in Massachusetts and a few in New Jersey during the fall and winter period *Culiseta melanura* larvae were also found. To what extent these larvae are used as food is not known but when fed *C. melanura* larvae in the laboratory they are readily eaten. Occasionally a few *Aedes canadensis* and *Aedes cinereus* larvae emerged concurrently with *Eucorethra* but not in sufficient numbers to provide any substantial food supply.

Matheson (1944) says of *E. underwoodi* "they are very destructive to mosquito larvae, especially early emerging *Aedes* species." In the New Jersey site considerable numbers of *Aedes* species emerged each spring which undoubtedly served as food for the maturing *Eucorethra* larvae present. Early *Aedes* species found in the vicinity of the individual breeding holes were as follows: *A. canadensis, A. abserratus, A. excrucians* and *A. punctor. A abserratus* is the most abundant species.

On several occasions no evident food source was visible other than cladocerans, nematodes and isopods. It is possible that cladocerans or nematodes might serve as a food source.

Laboratory Rearing

The larvae are very difficult to rear in the laboratory. All attempts made, while the author was employed in New Jersey, failed. Apparently the larvae cannot withstand water temperatures much above 60° F. as the observations in the breeding sites indicated temperatures only to 55° F. before pupation and adult emergence. Generally larvae lived for a short time in the laboratory and fed upon *Culiseta, Aedes* or *Culex* larvae provided but would suddenly appear unhealthy and succumb shortly thereafter. Aeration seemed to help prolong life but not long enough for larvae to pupate.

Many of the larvae collected in Bristol County, Massachusetts during November and December 1959 are still alive after living in jars in the laboratory as long as six weeks. These larvae, however, were kept at cooler temperatures which have not exceeded 68° F. and are usually lower.

As *Culiseta melanura* larvae are the most easily obtainable at all seasons in Bristol County they have been used for the main source of food. Quite often *Eucorethra* larvae were observed capturing *C. melanura* larvae at the water surface and swallowing them whole.

Pupae brought into the laboratory usually survive and a small series of adults was obtained from New Jersey reared specimens.

References Cited

1. COOK, E. F. 1956. The Nearctic Chaoborinae (Diptera: Culicidae) Univ. Minnesota Agr. Expt. Sta, Tech. Bull. 218:54–55.

2. FELT, E. P. 1904. Mosquitoes or Culicidae of New York State. N. Y. State Mus. Bull. 79: 357–360.

3. GETTING, V. A., and FEEMSTER, R. F. 1940. A survey of the mosquitoes of Massachusetts. Processed Report, Mass. Dept. Pub. Health. 127–128.

4. JOHANNSEN, O. A. 1903. Aquatic insects in New York State. N. Y. State Mus. Bull. 68:403–405.

5. MATHESON, R. 1944. Handbook of the mosquitoes of North America, pp. 92.

6. SMITH, MARION E. 1960. Personal communication. University of Massachusetts.

7. UNDERWOOD. Aug. 7, 1903. Science 182.

MAMMALIAN BURROWS AND VEGETATION AS SUMMER RESTING SITES OF THE MOSQUITOES *CULEX TARSALIS* AND *ANOPHELES FREEBORNI*

ROBERT F. HARWOOD AND J. E. HALFHILL[1]

Adults of the mosquito *Culex tarsalis* Coq. are frequently absent in man-made shelters (beneath bridges, in sheds) that serve as satisfactory resting sites for other mosquitoes. Considering the widespread distribution of this mosquito and the lack of man-made structures in some areas where it is abundant, there is no doubt that natural resting sites must be present. Because of the aridity and lack of vegetation of much typical *tarsalis* territory, it seemed that rock crevices and animal burrows could provide adequate shelter from conditions of high temperature and low humidity characteristic of the period when the mosquito is inactive. A study of burrows, rock fissures, and vegetation as resting sites for *Culex tarsalis* is recounted here, along with similar findings for *Anopheles freeborni* Aitken, the other principal mosquito present.

The sampling of rodent burrows and other natural resting sites of limited size by enclosing the area with a cage of netting and spraying chloroform into the site to drive out the mosquitoes, has been reported by Mortensen (1953), Loomis and Green (1959). Stuntz (1952, original not seen) collected *tarsalis* from rodent burrows in fall and winter, and Ryckman and Arakawa (1952) made winter collections of this and other mosquitoes by careful examination of the nest of wood rats. All such methods appear to be time-consuming, and subject to error through lack of visibility by the investigator.

To overcome these difficulties, a trap was developed to capture mosquitoes resting in burrows. The trapping chamber was constructed from a two-pound coffee can with an entrance cone in the bottom and a screen replacing the solid metal in the center of the cover (Fig. 1). The can was seated in a flange soldered to a half-inch mesh hardware cloth base. When set over a burrow or fissure, the hardware cloth permitted mosquitoes to enter the trap but prevented the access of small rodents. The hardware cloth served also

[1] Assistant Entomologist and graduate student in entomology respectively, Washington State University. This study was made possible through a grant (E-2253) from the National Institutes of Health, U. S. Public Health Service. Washington Agricultural Experiment Stations Scientific Paper 1924. Work was conducted under Project 1434.

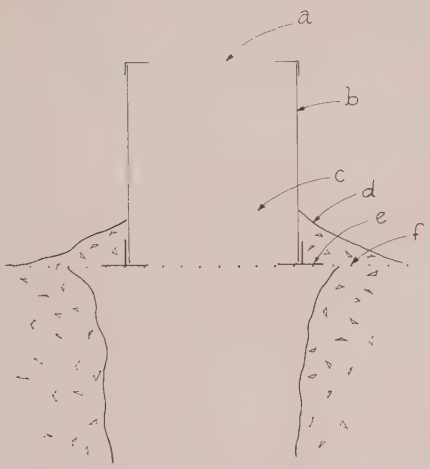

FIG. 1.—Diagram of burrow trap on burrow. a. fine mesh screen top. b. trap chamber from two pound coffee can. c. fine mesh screen entrance cone. d. earth seal. e. metal flange for seating trap chamber. f. hardware cloth base.

as a base for fastening the trap down with pegs or rocks. When placed on a site, light was prevented from entering the burrow outside of the trap chamber by placing soil around the base. A trap, similar in principle, was constructed with the flange attached to a canvas tarpaulin which could then be placed over foliage or other sizable resting sites. Metal tripod legs one foot in length were attached to the flange base of the tarpaulin trap to ensure that light was admitted from the highest point. The burrow and tarpaulin traps were placed on a suspected site in mid-afternoon, when mosquitoes were resting, and picked up at mid-morning or later the following day.

The present investigation was carried out in the Columbia Wildlife Refuge near Othello, Washington, during the summer of 1959. The mosquito population during this period was abnormally low, possibly because temperatures were lower than normal. Summer in the area is characterized by sunny, hot days and cool nights. The vegetation is primarily shrubby (sage brush, *Artemisia tridentata* Nutt.; rabbit brush, *Chrysothamnis* spp.), with willows (*Salix* spp.) confined to the drainage of Crab Creek and other minor watercourses. Since the refuge lies below the large O'Sullivan dam water impoundment and has a large irrigation canal along the eastern boundary, fluctuating water table causes temporary small ponds in which large numbers of mosquitoes may develop.

The vertebrate population of the refuge consists of both domestic and wild animals. Cattle and horses are found on two ranches, but the majority of the area is inhabited by rodents, lagomorphs, and birds. The rodents and rabbits are especially abundant in the broken rock scrabble lying at the base of basalt outcroppings (Fig. 2) and much of the study related here was concentrated in such environments.

FIG. 2.—Basalt cliff outcropping typical of the study area. Fissures are present in such cliffs, and animal burrows are dug into their bases. The loose basalt lying below cliffs also contains large numbers of animal burrows.

RESULTS. Using the tarpaulin trap modification, it was possible to capture considerable numbers of both sexes of *C. tarsalis* in vegetation during early summer, and an occasional *A. freeborni*. Suitable resting sites were often some distance from water in which larvae could have developed, and these held fewer spiders than were

TABLE 1.—Mosquitoes collected from rock fissures and animal burrows, Columbia Wildlife Refuge, Othello, Washington, 1959

Date	No. traps	*C. tarsalis* ♀	*C. tarsalis* ♂	*A. freeborni* ♀	*A. freeborni* ♂	*Culis. inornata* ♀	*Culis. inornata* ♂
July 1	4	19	47	6	4	—	—
7	10	10	70	2	5	1	—
9	2	21	13	13	16	—	—
13	4	3	11	47	6	—	—
21	8	46	26	36	47	—	—
23	4	7	4	0	0	—	—
28	15	4	2	226	58	—	—
30	2	0	0	0	0	—	—
Aug. 4	19	52	85	425	141	—	9
6	8	0	1	1	0	—	—
11	16	52	74	268	90	1	—
13	6	4	6	132	283	2	—
17	20	30	17	348	321	1	1
Total	118	246	356	1504	971	5	10
Mean	—	2.0	3.0	12.7	8.2	—	—

trapped in unsuitable vegetational cover. For example, in one area investigated on June 25, sedges at water's edge yielded no mosquitoes but large numbers of spiders. At the same time, 16 male and 2 female *C. tarsalis* (and no spiders) were captured in one trap placed in a wheat field some one hundred yards distant. Capture of *C. tarsalis* in vegetation dropped off in mid-July. From then on it was only possible to capture insignificant numbers in dense vegetation, such as clumps of sweet-clover, along stream banks.

Mammalian burrows and fissures in rocks that were habitations, or were often visited by mammals as evidenced by abundant droppings, proved to be adequate resting sites for mosquitoes. Principal animals were the bushy-tailed woodrat *Neotoma cinerea occidentalis* Baird, the yellow-bellied marmot *Marmota flaviventris avara* (Bangs), and the pygmy rabbit *Sylvilagus idahoensis* (Merriam). Promising sites were sampled at intervals of one week or longer, receiving particular attention if they consistently produced mosquitoes. Between July 1 and August 19, 118 burrow trap collections were made (Table 1). Each trap yielded a mean of 2.0 female and 3.0 male *Culex tarsalis* and 12.7 female and 8.2 male *Anopheles freeborni* per night. During this same period 5 female and 10 male *Culiseta inornata* were captured in these burrows.

It was obvious that some burrows consistently yielded more *C. tarsalis* than were found in the total mean catch. One such site consisted of a deep fissure at the base of an east-facing basalt cliff. The abundance of droppings here indicated continuous or frequent use by woodrats. In eight collections from July 4 through August 17, this site yielded a mean of 9.0 female and 13.1 male *C. tarsalis* per night, and 8.7 female and 11.0 male *A. freeborni* per night of trapping (Table 2).

TABLE 2.—Mosquitoes collected from a "woodrat burrow," Columbia Wildlife Refuge, Othello, Washington, 1959

Date	*C. tarsalis* ♀	*C. tarsalis* ♂	*A. freeborni* ♀	*A. freeborni* ♂
July 4	18	44	6	4
9	21	12	13	16
13	3	7	15	3
21	18	14	15	21
28	1	1	10	12
Aug. 4	1	20	3	13
11	6	1	2	5
17	4	6	6	14
Total	72	105	70	88
Mean	9.0	13.1	8.7	11.0

Marmot burrows were particularly attractive to *Anopheles freeborni*. In four collections from a burrow occupied by an adult marmot, a mean of 4.5 female and 7.0 male *C. tarsalis* and 210 female and 46.5 male *A. freeborni* were captured per night of trapping (Table 3).

TABLE 3.—Mosquitoes collected from a marmot burrow, Columbia Wildlife Refuge, Othello, Washington, 1959

Date	*C. tarsalis* ♀	*C. tarsalis* ♂	*A. freeborni* ♀	*A. freeborni* ♂
July 28	1	0	158	37
Aug. 4	5	8	249	69
11	10	19	200	28
17	2	1	233	52
Total	18	28	840	186
Mean	4.5	7.0	210.0	46.5

DISCUSSION. Some speculation is possible on what constitutes a suitable resting site for *Culex tarsalis*. Measurements of temperature, humidity, and light were made in resting sites and in adjacent exposed areas in early afternoon when the extremes of these conditions were attained. Temperature and humidity were measured with a psychrometric device that sampled air within a burrow at depths up to three feet from the entrance. Light was measured with a Model 756 Weston illumination meter. There was no great difference between burrows at the depth measured and the external environment with respect to temperature and humidity. For example, the external environment at 14.40 on July 16 was 104° F. and 13 percent R.H. in direct sunlight, whereas at three feet in a very productive marmot burrow the temperature was 103° F. and 17 percent R.H. There is little doubt that temperature was lower and humidity higher at mid-afternoon in burrows at depths greater than were measured (Schmidt-Nielsen & Schmidt-Nielsen, 1950).

Light intensity appears to be of major significance in determining the suitability of resting sites. In the study of a marmot burrow referred to above, the maximum measurable external light was 11,800 foot candles, whereas a similar measurement at three feet inside the burrow indicated a maximum of 10 foot candles. Rather similar light intensities were found in all productive resting sites for *Culex tarsalis*. The best sites had a maximum measurable light intensity of ten foot candles or less in mid-afternoon. This was the case whether these sites were in burrows or in dense vegetation.

Based on observations made during this single summer, a few generalizations can be made concerning which animal burrows constitute the best summer resting sites for *Culex tarsalis*. The best burrow sites were in contact with the soil. Burrows at the base of cliffs, at the ground level, invariably held more *C. tarsalis* than adjacent fissures within such cliffs at some distance from the ground. Burrows in the ground, particularly rabbit dens in the shade of sagebrush, were quite productive, though ground burrows inhabited by marmots appeared more attractive to *A. freeborni*.

There is some question as to whether the occupants of mammalian burrows are of significance with respect to the maintenance of encephalitis viruses. Female *Culex tarsalis* were frequently gravid or replete with blood when captured in burrows. The blood appeared digested to a degree where a good precipitin test for animal source was impossible. The fact that males were also present, frequently in large numbers, should indicate that such sites were not necessarily chosen because of a particular host attractiveness. However, as Hubert *et al.* (1954) have pointed out, *C. tarsalis* readily feeds on any of a large variety of vertebrates in the laboratory. For this reason, any factors providing a close proximity of the mosquito with vertebrates should be viewed with suspicion with respect to the maintenance of encephalitis viruses.

SUMMARY. Vegetation, mammalian burrows, and rock fissures were examined in the Columbia Wildlife Refuge near Othello, Washington, as summer resting sites for mosquitoes. Dense vegetation provided satisfactory resting sites for *C. tar-*

salis through mid-July. Mammalian burrows and rock fissures provided shelter for *C. tarsalis* and *A. freeborni* throughout the period of study. *C. tarsalis* preferred burrows in ground contact for resting, *A. freeborni* showed a preference for marmot burrows. While temperature and humidity within burrows to a depth of three feet varied little from the external environment during mid-afternoon, the maximum light intensity of good resting sites was less than ten foot candles during the same period.

ACKNOWLEDGMENT

Special thanks are due Mr. Paul Steel, manager of the Columbia Wildlife Refuge, U.S.F.W.S., and other personnel of that station, for their wholehearted cooperation during the conduct of this study.

References Cited

HUBERT, A. A., RUSH, W. A., and BRENNAN, J. M. 1954. Simplified techniques for the continuous rearing of *Culex tarsalis* with additional notes and observations. Mosq. News 14:75–8.

LOOMIS, E. C. and GREEN, D. H. 1959. Ecological observations on *Culex tarsalis* Coquillett and other mosquitoes in the Delta region of the Central Valley of California, 1953–1956 (Diptera: Culicidae). Ann. Ent. Soc. Amer. 52:524–33.

MORTENSEN, E. W. 1953. Observations on the overwintering habits of *Culex tarsalis* Coquillett in nature. Proc. and Papers 21st Ann. Conf. Calif. Mosq. Control Assoc., pp. 59–60.

RYCKMAN, R. E. and ARAKAWA, K. Y. 1952. Additional collections of mosquitoes from wood rat's nests. Pan-Pac. Ent. 28:105–6.

SCHMIDT-NIELSON, B. and SCHMIDT-NIELSON, K. 1950. Evaporative water loss in desert rodents in their natural habitat. Ecology 31:75–85.

STUNTZ, J. R. 1952. Observations of the distribution and overwintering behavior of adult *Culex tarsalis* and *C. stigmatosoma* during 1951. Report (unpublished) of Rice Field Mosq. Research Proj., Calif. Mosq. Control Assoc., pp. 1–17.

EFFECT OF TEMPERATURE ON RATE OF RELEASE OF TOXICANTS FROM GRANULES AND ON BREAKDOWN OF CERTAIN INSECTICIDES IN WATER [1]

MIR S. MULLA AND HAROLD AXELROD
University of California Citrus Experiment Station, Riverside

INTRODUCTION. The feasibility of using granular formulations of chlorinated hydrocarbon insecticides for the control of rice-field mosquitoes was investigated for the first time less than a decade ago (Whitehead 1951). It was suggested that aqueous sprays incompletely penetrated the plant canopy and that they resulted in erratic and sometimes poor control of *Psorophora* mosquitoes breeding in rice paddies. Granular insecticides were observed to penetrate the plant foliage and thus to reach the water below the plant canopy where the insects were breeding.

LaBrecque and Goulding (1954) obtained better and longer control of *Culicoides furens* (Poey) with granular BHC and dieldrin than with sprays, in a densely foliated salt marsh in Florida. Keller *et al.* (1954) attributed failure of sprays to control larvae of *Aedes taeniorhynchus* (Wied.) and of *A. sollicitans* (Wlkr.) in salt marshes to incomplete penetration of sprays through the dense foliage.

The efficiency of granular insecticides was demonstrated in the laboratory by obtaining good kill of *Anopheles quadri-*

[1] Studies supported by a grant-in-aid from Fresno, Kern, and Westside Mosquito Abatement Districts in California. Paper No. 1198, University of California Citrus Experiment Station, Riverside, California.

maculatus Say with granular insecticides (LaBrecque *et al.* 1956). The rate of release or the temperature at which the tests were performed was not made known in this work. The results are probably dependent on the extent of release of toxicants as well as on the toxicity and stability of various materials studied. Hilsenhoff (1959) investigated the efficiency of granular insecticides against *Tendipes plumosus* (Linnaeus) with the water temperature maintained at 20° C. during the testing period.

Weidhaas (1957) initiated studies on the rate of release of parathion, EPN, and chlorothion into water. These studies were conducted at temperatures of 80° to 90° F. Good release was generally obtained for parathion and chlorothion, but release for EPN was poor.

In preliminary studies on the efficiency and performance of granular formulations, Mulla and Axelrod (1959) demonstrated the rate of release of organophosphate insecticides to be markedly influenced by the temperature of the water to which the granules were added. The studies reported herein concern the relation of temperature to the rate of release of toxicants from granular materials into water. To study this relationship more thoroughly, the rate of breakdown of some insecticides at various temperatures in water was also investigated.

MATERIALS AND METHODS. Samples of granular materials were prepared in the laboratory in a small rotary unit. The details of the formulating procedure of granules are presented elsewhere (Mulla and Axelrod 1960). Batches of 20–40 grams of the formulated materials were prepared for each test. The finished granular product was dust-free and was tested for rate of release 1 to 3 days after formulating.

Two percent granular parathion, Bayer 29493 (*O,O*-dimethyl *O*-3-methyl-4-methyl-4-methylthiophenyl phosphorothioate) and AC 5727 (*m*-isopropylphenyl N-methylcarbamate) and 5 percent granular malathion were made by preparing solutions from the technical materials, using isopropanol and Espesol 5 as solvents and impregnating the solution onto the granules. The solvents were used at 10 percent concentration of the finished product. The carriers used in all the experiments were attapulgite clay granules 30/60 mesh of the AA-LVM and AA-RVM type (Floridin Company, Tallahassee, Florida).

To determine the rate of release of the toxicants from the granules, various amounts of the 2 percent and 5 percent products were placed in a 1-gallon mayonnaise jar containing 3500 ml. of tap water having a pH of 8–8.5 and a height of 8.25 inches. This amounted to a 5 ppm concentration of the active ingredients of parathion, Bayer 29493, and AC 5727 in the water, provided the total quantities of the toxicants present were released. An amount of the 5 percent malathion formulation was added to the jar to yield a theoretical 20-ppm concentration of malathion in the water. Disturbance or stirring of the water was avoided after addition of the granules.

In the malathion and parathion tests, 25 ml. of water were aspirated from the top and bottom portions (1 inch above the granules) of the water column and composited for further dilution. To make the final dilutions, aliquots of the composite sample were added to each of three pint cups containing 100 ml. of tap water and 25 fourth instar larvae of *Culex quinquefasciatus* Say. This resulted in obtaining a final theoretical concentration of 0.02 ppm for parathion, 0.3 ppm for malathion granules and 0.15 ppm for malathion emulsion. Bayer 29493 and AC 5727 granules were tested at 0.05 ppm and 0.1 ppm of final theoretical concentration. The emulsifiable concentrate formulations of these materials were tested at 0.01 ppm and 0.07 ppm final concentrations, respectively.

The mosquito larvae were exposed to the toxicants at a temperature of 75°–78° F., and the mortality was recorded 24 hours later. The magnitude of release at each interval and each temperature was calculated from the observed mortality of larvae by reference to dosage mortality lines established for each of the toxicants and the total amount of each added to the jar. The maximum release for the para-

thion, malathion, and AC 5727 formulations was 60+ percent. The designation in the figures below is presented as such, indicating the release to be higher than 60 percent. The maximum release obtained for Bayer 29493 was more than 30 percent.

For determining the rate of breakdown of the four toxicants employed in our tests, the same concentration of each material as for granules was obtained by adding small volumes of the emulsifiable concentrates to the water in the 1-gallon jar and stirring thoroughly. Prior to taking aliquots from the bottom and top portions, the water was completely agitated with a stirring rod. The following procedure was the same as that employed in the evaluation of granular materials. The contents of the toxicants in water were calculated by utilizing dosage mortality lines established for these materials against mosquito larvae used as bioassay test insects.

Tests on the solubility of each material in water were also conducted. Acetone solutions of the toxicants were added to water at the lowest tempertaure under which the materials were tested either as granules or emulsions. Parathion and Bayer 29493 were made at a concentration of 5 ppm; and malathion was made at a concentration of 20 ppm. Mosquito larvae bioassay tests indicated the full amount of the toxicants to be present after 2–3 hours. These tests showed that the solubility of these materials at the lowest temperature was higher than the concentrations used in the tests here. AC 5727 was added at 5 ppm and it was determined to be soluble in water at a concentration of 3.5 ppm, at 70° F. A release of 60–70 percent of this material from its granules

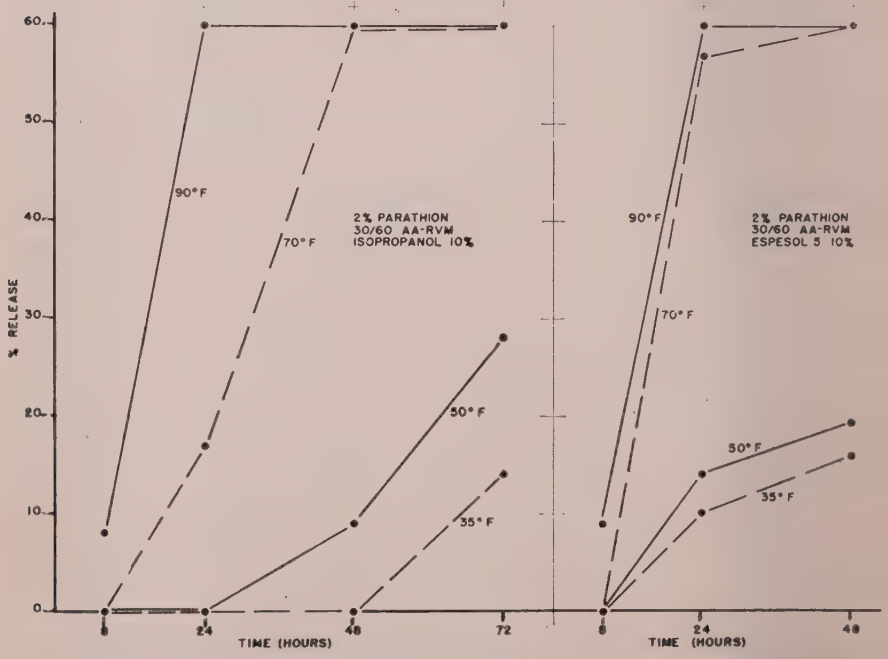

FIG. 1.—Pattern of release of parathion from granular formulations in water at various temperatures. The plus sign (+) indicates a release of > 60 percent.

as regulated by its solubility would represent 100 percent release of this toxicant.

RESULTS AND DISCUSSION. EFFECT OF TEMPERATURE ON RELEASE OF TOXICANTS. Parathion when impregnated on 30/60 AA-RVM attapulgite granules, using isopropanol and Espesol 5 as solvents for impregnation, yielded higher release at the higher temperatures (Fig. 1). The trend of release at the various temperatures was similar with both solvents, except that the release of the formulation using isopropanol as solvent at a temperature of 70° F. at the 24-hour interval was considerably lower than the release from the Espesol 5 formulation tested at the same temperature and the same period of exposure. The overall speed of release of parathion at 35°, 50° and 70° F. is greater for each sampling interval for the Espesol 5 formulation than for the isopropanol formulation. The differences, though small, are consistent over the entire range of the experimental temperatures.

The trend of the release of malathion for the three types of formulations used in the experiments was different from that of parathion. Here the release of malathion reached a maximum at the 8- or 24-hour period for temperatures of 80°, 90° and 100° F. and then started to decline rapidly (Fig. 2). At temperatures of 90° and 100° F., malathion hydrolyzed so rapidly that no appreciable quantities of malathion were detected after three days at a level of testing where 60 percent or more release was obtained initially. The overall release of the isopropanol formulation at 70° and 90° F. was lower than that of the Espesol 5 formulation.

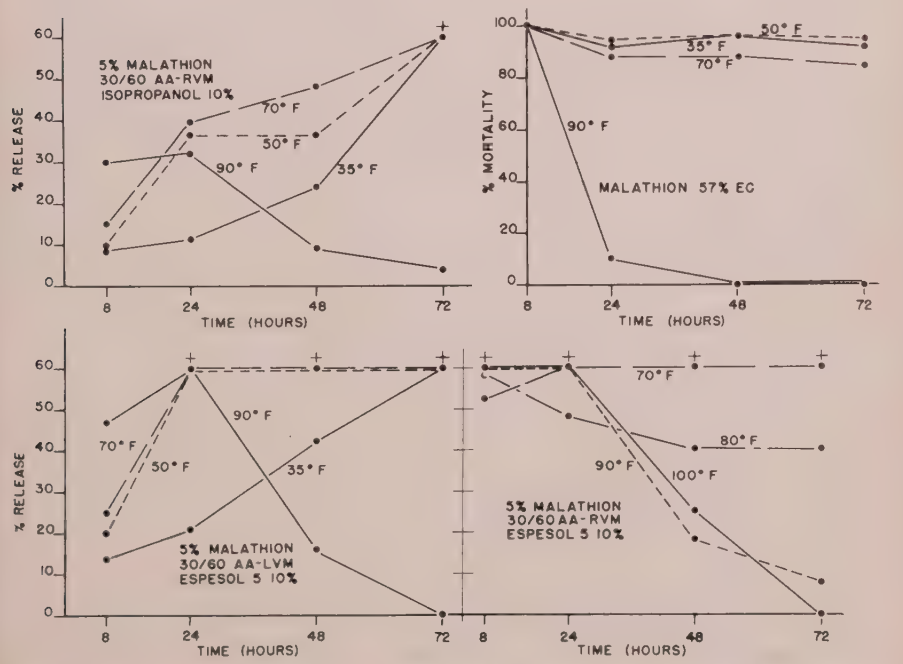

FIG. 2.—Rate of apparent release of malathion from its granular formulations, and the degree of breakdown in the emulsifiable concentrate form at various temperatures. The plus sign (+) indicates a release of > 60 percent.

The rapid decrease in the amount of malathion in water was at first thought to be induced by the type of granular formulation. However, further studies on the behavior of emulsifiable concentrate formulation of malathion revealed a similar rapid breakdown of malathion in the water at higher temperatures (see below).

The behavior of granular Bayer 29493 was found to be patterned after that of parathion, except that the magnitude of release of the former was much lower than that of the latter. The extent of release of Bayer 29493 from granules was also found to be a function of the temperature. The magnitude of release at all sampling periods was higher at higher temperatures (Fig. 3).

The release of AC 5727 from its granular formulation was completed at 8 hours' exposure for all temperatures (see Fig. 3). The level of AC 5727 in the water decreased after 8 hours and dropped rapidly at temperatures of 90° and 100° F. This rapid disappearance of AC 5727 was also determined for the emulsifiable concentrate formulation of this material at 100° F.

BREAKDOWN AT HIGH TEMPERATURES. Studies on the release of malathion from granular formulations established the fact that the malathion release from these formulations decreased in time within the temperature range of 70° to 100° F. This phenomenon was thought at first to be due to the readsorption characteristic of certain granular carriers as reported by Weidhaas (1957). However, studies on the quantity of malathion using emulsifiable concentrate formulations demonstrated a rapid decrease in the quantity of malathion in water between the time interval of 8 and 24 hours at 90° F. (see Fig. 2). There was

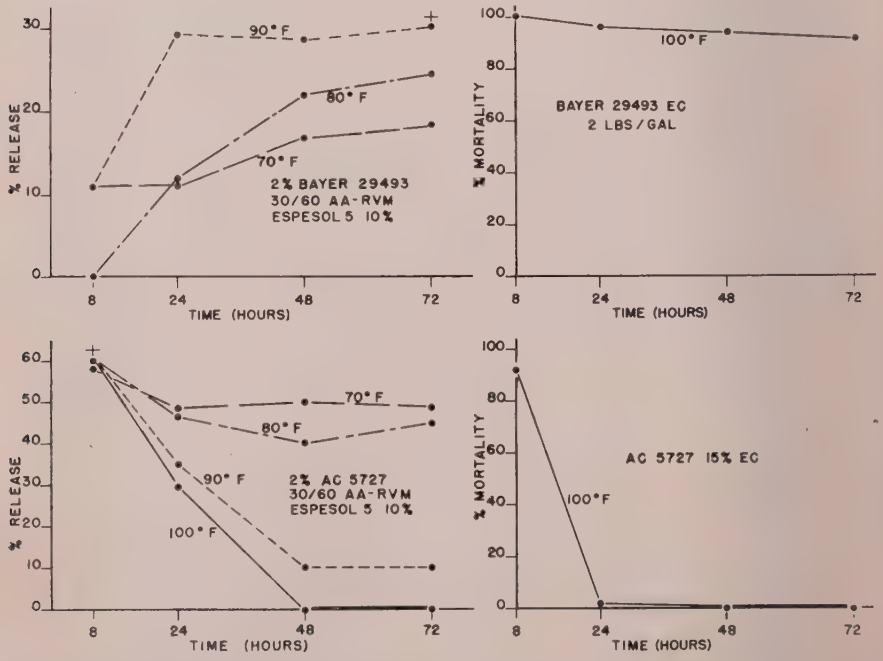

FIG. 3.—Behavior of granular and emulsifiable concentrates of Bayer 29493 and AC 5727 in water at various temperatures. The plus sign (+) indicates that the release was > 30 percent and < 60 percent for Bayer 29439 and > 60 percent for AC 5727.

also a slight breakdown of malathion at a temperature of 70° F., but appreciable breakdown seems to result at higher temperatures.

Similar rapid decrease in the amount of AC 5727 was observed when the granular formulation of this material was tested for its release pattern at higher temperatures. The breakdown of this material was rather slight at 70° F. and 80° F., in comparison with that of malathion. At 90° and 100° F. there was a rapid breakdown of AC 5727 comparable to that of malathion. It should be pointed out that the rate of breakdown of the emulsifiable concentrate formulation of AC 5727 at 100° F. is greater at the beginning than that of its granular formulation. The granular formulation thus seems to increase the longevity of unstable materials somewhat over that of its emulsifiable concentrate formulation by not releasing the total amount of the toxicant into the water at once (see Fig. 3). Similar trends have also been observed for the two kinds of malathion formulations. A regulated release of unstable materials into water can be obtained by selecting the proper kind of solvent (Mulla and Axelrod 1960), thus lengthening the life of such materials in water over that of their emulsifiable concentrate formulations.

The breakdown of Bayer 29493 in the form of emulsifiable concentrate is relatively slight at 100° F. The release of this material from its granular formulation was observed to increase steadily with respect to time at all temperatures of the test (see Fig. 3). Because of the slight breakdown of this material at the elevated temperature (100° F.) it is considered to be stable. The stability of parathion under the test conditions at 100° F. was studied, but the magnitude of the breakdown of this material in water was negligible up to a period of 72 hours duration.

For mosquito larviciding programs under field conditions, stable materials as either granular or emulsifiable concentrate formulations are desirable. Stable materials not only maintain relatively constant concentration in infested waters but also take care of reinfestation for a longer period following treatments, as compared to relatively unstable toxicants. The longevity of many mosquito larvicides in the field has not been adequately studied. Studies in this direction should lead to the selection of more efficient materials and formulations as mosquito larvicides.

References

CHAPMAN, H. C. 1955. Tests with granulated and systemic insecticides against *Mansonia* larvae. Mosq. News 15(4):204–6.

HILSENHOFF, WILLIAM L. 1959. The evaluation of insecticides for the control of *Tendipes plumosus* (Linnaeus). J. Econ. Ent. 52(2):331–2.

KELLER, J. C., CHAPMAN, H. C., and LABRECQUE, G. C. 1954. Tests with granulated insecticides for the control of salt marsh mosquito larvae. Mosq. News 14(1):5–9.

LABRECQUE, G. C., and GOULDING, R. L. 1954. Tests with granulated BHC and dieldrin for controlling sand fly larvae. Mosq. News 14(1):20–2.

LABRECQUE, G. C., NOE, J. R., and GAHAN, J. B. 1956. Effectiveness of insecticides on granular clay carriers against mosquito larvae. Mosq. News 16(1):1–3.

MULLA, MIR S., and AXELROD, HAROLD. 1959. Granular formulations of insecticides and factors influencing their efficiency in mosquito control. Calif. Mosquito Control Assoc. Proc. 1959:79–82.

MULLA,, MIR S., and AXELROD, HAROLD. 1960. Efficiency of granulated insecticides influenced by solvents used for impregnation. J. Econ. Ent. (In press.)

WEIDHAAS, D. E. 1957. Laboratory study of the release of some organic phosphorus insecticides into water from granular formulations. Mosq. News 17(3):168–72.

WHITEHEAD, F. E. 1951. Rice field mosquito control by pellet-borne insecticides. Arkansas Agr. Expt. Sta. Bull. 511. 30 pp.

LABORATORY STUDIES OF RESIDUAL TOXIC EFFECTS OF MALATHION GRANULES ON *CULEX PIPIENS QUINQUEFASCIATUS* SAY LARVAE[1]

LALLAN RAI AND LAWRENCE L. LEWALLEN
Consolidated Mosquito Abatement District, Selma, California
and
California State Department of Public Health, Fresno, California

The results reported by Gjullin and Lewallen (1958) suggest a long term residual effect of malathion granules on mosquito larvae when the granules are applied at a dosage much larger than is usually used. This situation was encountered in a pasture in the Fresno Mosquito Abatement District, Fresno, California. The usual spray application of 0.5 pound of malathion to an acre began to prove ineffective against *Culex tarsalis* Coq. larvae in the pasture in the summer of 1956. The pasture was heavily treated with malathion pellets in August after which spray applications of malathion at 0.5 lb./acre were found to be effective and remained so for the rest of the mosquito season. Water from this pasture was also toxic to *Aedes nigromaculis* (Ludlow) larvae in September of that year.

Samples of water from the pasture which were taken in June of the following year also were toxic to *C. p. quinquefasciatus* larvae in larboratory tests. The results of several kinds of experiments on this water led the authors to the conclusion that the toxic effect was due to some kind of chemical rather than to a disease agent.

The present paper presents the results of further tests on water from this pasture. The hypothesis that the reported toxic effect was due to the malathion granules applied is also examined in the light of experiments on the residual action of this compound.

MATERIALS AND METHODS. The mosquitoes used in these tests were 4th instar *Culex pipiens quinquefasciatus* Say larvae which are designated the Bakersfield susceptible strain. They were originally collected in Kern County in 1952 and were colonized at the Kern Mosquito Abatement District, Bakersfield, California. They have been under cultivation at the Fresno Field Station of the Bureau of Vector Control since 1955.

Two techniques were used for exposing larvae to test solutions, the paper cup technique and the residual technique. In the paper cup method, 25 larvae were placed into 100 ml. of test solution in 4 oz. paper cups.[2] Equal numbers of "control" larvae were placed in an equal volume of tap water. Exposure was for 24 hours after which mortality was judged by lack of movement of the larvae. These and all other tests reported here were done at 23° to 28° C.

The residual technique was used to determine how long insecticidal granules were toxic to mosquito larvae. The tests were carried out with the granules exposed to mud to simulate conditions in the field. A circular enamel pan 35 cm. in diameter and 12.5 cm. deep was used for this purpose. The pan was filled with mud from the suspected breeding place to a depth of 5 cm. The mud was then covered with water from the same breeding place to a depth of about 5 cm. The weighed amount of granules to be used was sprinkled evenly over the water surface with the aid of forceps. The larvae to be exposed were placed in wire baskets (tea strainers) which were then lowered into the test medium. The baskets were

[1] An expression of appreciation is due Dr. A. Ralph Barr, State Department of Public Health, Fresno, California, for his help in writing the manuscript and to Sylvia Barr for preparation of the illustration.

[2] Dixie Cup Company, Anaheim, California.

supported from sticks placed across the top of the pan. Twenty-five larvae were placed in each of three baskets for a single day's test. There were, therefore, three replicates in each day's test. The larvae were exposed for 24 hours after which time the baskets were removed for examination. The baskets in these tests were used to recover the larvae which were difficult to see against the dark background provided by the mud.

After a test pan was set up as described, the medium was tested daily (usually) until it was no longer toxic to mosquito larvae. The pan was then set up with a different dosage of granules and the test run again. Three dosages in all were used. Controls were run simultaneously in 800 ml. beakers using similar mixtures of mud and water but without insecticides. The pH of the water in these tests ranged from 7.1 to 7.5.

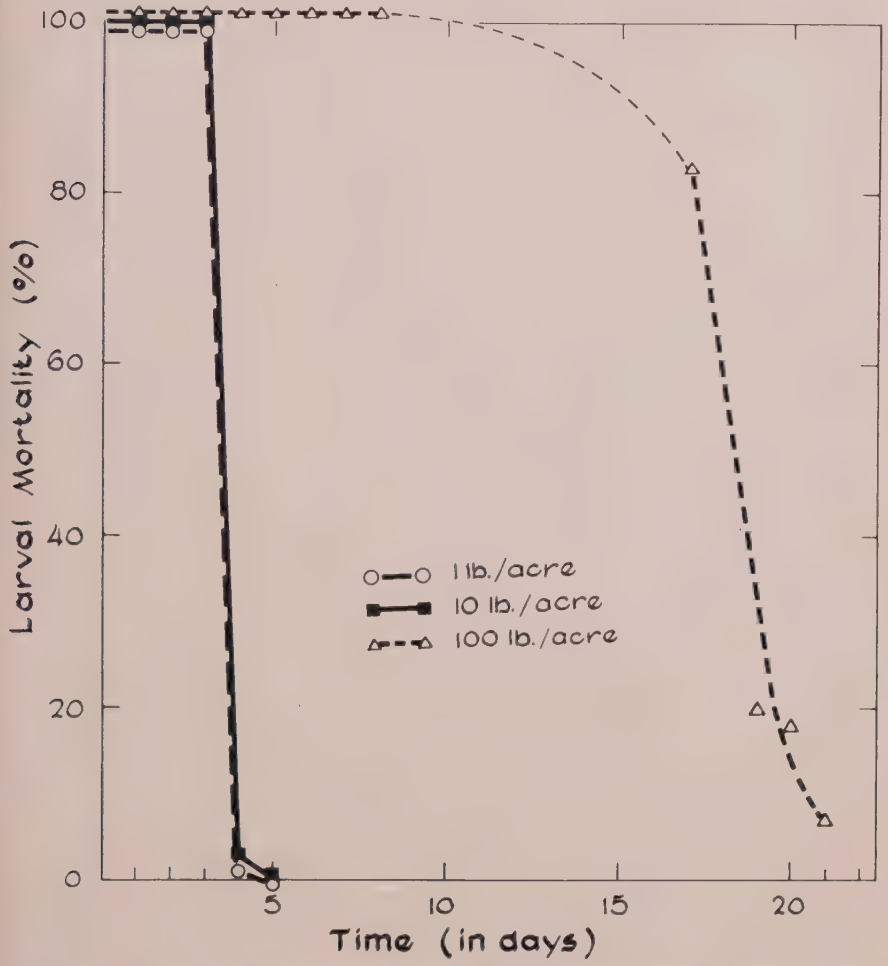

FIG. 1.– Residual effects of malathion granules applied at different dosage levels to 4th instar larvae of *Culex pipiens quinquefasciatus* Say.

Mud samples were tested for toxicity by adding 350 gm. to 400 ml. of pasture or tap water in an 800 ml. beaker, mixing, and allowing to settle. Larvae were exposed in wire baskets as above.

The granules used in these tests were Attaclay—AALUM, 24/48 mesh containing 10 percent by weight of malathion.[3] All dosages mentioned are in terms of weight of toxicant used, not weight of granules.

RESULTS. Collections of water and mud from the pasture studied by Gjullin and Lewallen were made on July 9, 1959 to determine whether they still had a toxic effect on mosquito larvae. Four samples of water were tested by the paper cup technique with two control samples in tap water. No larvae of the experimental or control series died.

Two samples of mud were tested, one combined with pasture water and the other with tap water. All of the larvae exposed in these tests also lived.

The results of tests on the residual effectiveness of malathion granules are shown in Figure 1. Malathion applied at 1 or 10 lbs./acre killed larvae for three days after which its effectiveness disappeared almost completely. When malathion at 100 lbs./acre was used, all larvae exposed during the first week died. The mortality rate dropped to 83 percent by the 17th day after the application, and to 20 percent by the 19th day. Practically all larvae survived which were exposed three weeks after the application.

DISCUSSION. The above tests indicate that the presumed residual effect noted by Gjullin and Lewallen in 1956 and 1957 was no longer present in 1959. These authors described what was apparently a residual action of malathion granules lasting for several months in the field. There is some doubt, however, as to the type and quantity of granules used. It seems likely that the dosage of malathion used by these authors did not exceed 100 lbs./acre as was used in the present tests. It also seems likely that the type of granules used by these authors did not differ markedly from the type used in the present tests. It, therefore, is unlikely that the toxic effects noted by Gjullin and Lewallen in 1957 was due to the granules applied in 1956.

SUMMARY. The residual toxicity of malathion granules to *C. pipiens quinquefasciatus* Say larvae in a mud-water complex was studied under laboratory conditions. Malathion applied at 1 and 10 lbs./acre was effective over a three-day period; at 100 lbs./acre it was toxic for more than 17 days.

Literature Cited

GJULLIN, C. M., and LEWALLEN, LAWRENCE L. 1958. Report on cooperative mosquito research in California. Calif. Mosquito Control Assn., Proc. and Pap. Ann. Conf. 26:28–31.

[3] The writers wish to express their gratitude to Sunland Industries, Fresno, California, for supplying these granules.

DESPLAINES VALLEY MOSQUITO ABATEMENT DISTRICT

8130 Ogden Avenue, Lyons, Illinois

Member of American Mosquito Control Association

Trustees

Otto McFeely, President; Charles F. Scheel, Vice-President; John J. Callahan, Secretary; Francis P. Creadon, Treasurer; William E. Goersmeyer, Ass't Secretary.

Franklin C. Wray, Technical Director

The District was created under state law adopted in 1927 by the General Assembly of Illinois. The District has functioned for thirty-two years.

OPERATIONAL AND SCIENTIFIC NOTES

Treating Water Areas with Granular Insecticides

William L. Hilsenhoff, Department of Entomology, University of Wisconsin, Madison. Approved for publication by the Director of the Wisconsin Agricultural Experiment Station.

(The author was a member of a cooperative research team composed of Dr. R. J. Dicke, Project Director, University of Wisconsin, and Dr. Daniel Palm and Dr. Jacob Shapiro, Wisconsin State College, Oshkosh. Supported in part by Winnebago Lake Fly Research, Inc.)

A rapid method has been developed for treating water areas with low dosages of granular insecticides from a boat. The principle of the method is to pump water from the lake and force it through a Venturi type filter pump. The filter pump acts as a hose nozzle, and a 35-foot spray of water can be easily obtained with a small water pump. Granules introduced into the modified side arm of the filter pump by gravity feed from a reservoir, mix with the water and are sprayed onto the surface of the lake. Since the water from the pump acts as a diluent as well as a carrier, small dosages of granules can be quite evenly distributed.

Equipment suitable for experimental applications (Fig. 1) can be easily constructed. A ring fitting a wide mouth Mason jar (B) is soldered to the inside of a 4-1/2 inch metal funnel (C) so that a Mason jar (A) can be screwed into the top of the funnel. The Mason jar is used as a reservoir for the granules. The tip of the funnel is connected to one arm of a small, 3/16 inch I.D. glass "Y" (F) by a 1-1/2 inch length of 1/4 inch I.D. plastic tubing (E). A pinch clamp (D) is placed on the plastic tubing to retain or release granules from the reservoir. The other arm of the glass "Y" is open to prevent a partial vacuum from forming in the reservoir. The stem of the glass "Y" is connected by 1/4 inch I.D. plastic tubing (G) to the modified side arm (H) of a 5-3/8 inch filter pump (I), the normal side arm having been replaced by a 2 inch brass arm with a bore 1/8 inch in diameter. A 3/4 by 1/2 inch filter pump coupling (J) is used to connect the filter pump to the output hose (K) from the water pump.

A gear-type water pump powered by a 1-cylinder gasoline motor forces water through the filter pump at a rate of 2 gallons per minute. This produces a maximum stream of water 35 feet in length, with most of the water falling between 27 and 33 feet from the filter pump barrel. Opening the pinchcock below the reservoir allows 30/60 mesh granules to flow by gravity into the side arm of the pump at a rate of 1 pound per seven minutes. The rate of application is regulated by the speed of the boat and the width of the swath to which granules are applied.

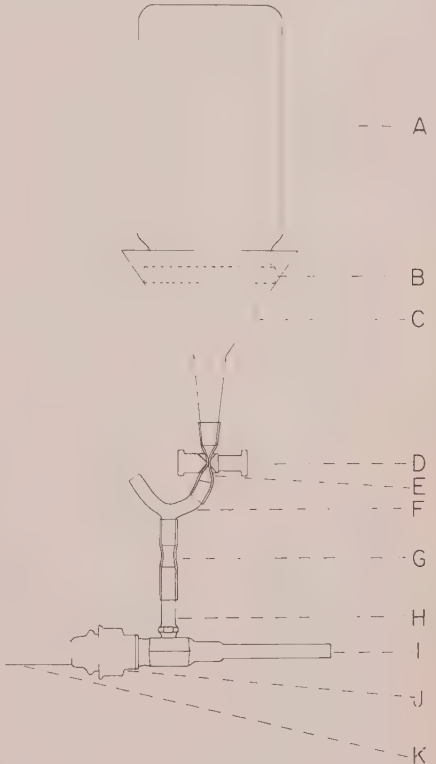

Fig. 1.—A—one quart wide mouth Mason jar. B—ring for wide mouth Mason jar. C—4-1/2 inch metal funnel. D—pinch clamp. E and G—1-1/2 inch length of 1/4 inch I.D. plastic tubing. F—small, 3/16 inch I.D. glass "Y." H—modified filter pump arm. I—5-3/8 inch filter pump. J—3/4 by 1/2 inch filter pump coupling. K—hose from water pump.

Although designed for the treatment of small experimental acreages, this method of lake treat-

ment could be adapted to commercial use as well. This would be done by increasing the size of the filter pump, the volume and pressure of water pumped through it, the size of the granule reservoir, and the rate of flow of the granules. Advantages over aircraft application would include a more even distribution of the granules, elimination of accidental insecticide contamination of adjacent land areas, and possible financial savings through the use of available personnel and less expensive equipment.

EFFECTIVENESS OF PYRETHRUM SPRAYS AGAINST MOSQUITOES AND HOUSE FLIES IN DARKNESS AND LIGHT

J. H. FALES, O. F. BODENSTEIN, and R. K. BURALL, Entomology Research Division, Agr. Res. Serv., U.S.D.A.

During the course of aerosol studies at Beltsville, Maryland, against adult mosquitoes at practical use dosages (7 grams per 1000 cubic feet) in large darkened spaces, it was decided to employ house flies (*Musca domestica* L.) also. These tests indicated that darkness reduced the effectiveness of aerosols against house flies but not against mosquitoes. A Peet-Grady chamber was then used to study the effect of light and darkness on knockdown and mortality of laboratory-reared nonresistant free-flying adult mosquitoes and house flies (NAIDM 1948). Tests were conducted with odorless kerosene sprays containing pyrethrins at 0.033 mg./ml. against *Aedes aegypti* (L.) and at 0.8 mg./ml. against *Culex pipiens* L. Both concentrations had been used in prior mosquito studies (Fales *et al.* 1952, 1954). The dosage was 13.9 ml. per 1000 cubic feet. The Official Test Insecticide, which contains 1 mg./ml. of pyrethrins and another spray containing 2 mg./ml. were tested against house flies at the standard Peet-Grady dosage of 55.6 ml. per 1000 cubic feet. Ten-minute exposures were used in all the tests.

The tests without light were made in complete darkness. This was easy to accomplish, since the Peet-Grady chamber was located in a windowless room. In the tests with light a single 200-watt incandescent light was used. The tests under both conditions were performed at temperatures between 27° and 30° C. The sprays were not delivered until 5 minutes after the insects were released into the chamber.

The results of this study are given in Table 1. With both species of mosquitoes no difference in mortality of either males or females occurred when exposed in darkness or light, but the knockdown of *Aedes aegypti* was less in darkness. Much lower kills and knockdowns of house flies were obtained in darkness than in light.

TABLE 1.—Comparison of effectiveness of pyrethrum sprays against mosquitoes and house flies in darkness and in light

Concentration (mg./ml.)	Condition of chamber	Percent knockdown in 10 minutes	Percent kill in 1 day	
			Males	Females
		Aedes aegypti (3 Tests)		
0.033	Dark	66	32	27
ditto	Light	88	33	31
		Culex pipiens (3 Tests)		
0.8	Dark	98	88	52
ditto	Light	97	88	53
		Musca domestica (4 Tests)		
			Total	
1.0	Dark	83	2	
ditto	Light	96	17	
2.0	Dark	92	20	
ditto	Light	97	45	

Under the conditions of these tests it can be concluded that mosquitoes can be controlled by space sprays to the same degree in darkness as in light, but that this is not true of house flies.

References Cited

FALES, J. H., BODENSTEIN, O. F., and NELSON, R. H. 1954. The synergistic action of sulfoxide in insecticide sprays and aerosols. Jour. Econ. Ent. 47(1):27–29.

FALES, J. H., BODENSTEIN, O. F., and PIQUETT, P. G. 1952. Effectiveness of allethrin and pyrethrins as sprays against three species of mosquitoes. Jour. Econ. Ent. 45(4):743.

A CAGE FOR THE EXPERIMENTAL TRANSMISSION OF MOSQUITO-BORNE PATHOGENS

BRUCE F. ELDRIDGE and DOUGLAS J. GOULD, Department of Entomology, Walter Reed Army Institute of Research, Washington, D. C.

Studies on the transmission of mosquito-borne viruses have led to the design of an improved cage for the feeding of individual or groups of infected mosquitoes on chicks of two weeks of age or less. Small animals other than chicks can be used with slight modifications. This cage offers several advantages over previously designed cages. The most important innovation is the arrangement for placement of the chick. All feeding takes place on the bird's leg which is inserted through a hole in the top of the cage. An earlier cage used by us employed an arrangement which required a surface of the chick to be clipped so as to expose an area of bare skin. The chick was strapped to the cage with its clipped surface in contact with a layer of screen or netting through which the mosquito was required to feed. We had little success in getting certain species of mosquitoes to feed under this arrangement and furthermore, the process of clipping is extremely time consuming, especially when large numbers of birds are involved. Since the adoption of the cage described here, the percentage of feeds has markedly increased. The cage has the further advantages of being inexpensive, easily fabricated, and easily cleaned. Since it is able to withstand repeated steam sterilization, it can be re-used indefinitely.

The cage consists of a one-pint wide-mouth Mason jar (Fig. 1, A) and a standard wide-mouth Mason screw-type ring into which has been spot soldered a 3-1/4 inch diameter disc of 18 gauge brass screen (Fig. 1, B). A 7/8 inch diameter hole is punched eccentrically into the screen disc and a 1-1/8 inch outside diameter, 5/8 inch inside diameter rubber grommet (obtainable from Herman H. Smith, Inc. 2326 Nostrand Ave., Brooklyn, N. Y. Cat. #2187) is fitted into the hole (Fig. 1, C). The pint-sized jar is of adequate size for up to 100 mosquitoes. A quart-sized jar may be substituted for larger numbers.

Mosquitoes to be fed are introduced into the cage by means of an aspirator inserted through the grommet hole. When the aspirator is removed, a size no. 0 rubber stopper is inserted into the grommet hole. We pour a layer of water about an inch deep into the jar through the screen. This serves to provide a medium for oviposition and also increases the humidity within the cage. To feed mosquitoes, a 5/8 inch long piece of 5/8 inch outside diameter, 3/16 inch inside diameter rubber tubing which has been split lengthwise on one side, is placed around the leg of a chick (Fig. 1, D). The rubber stopper is removed from the cage, and the encased chick leg inserted into the jar. The chick leg and the piece of rubber tubing snugly fill the grommet hole. We place a small piece of masking tape across the grommet where the split in the rubber tubing occurs. This eliminates any possibility of the escape of the infected mosquito. Another piece of masking tape holds down the free leg and a longer piece holds the bird down on the jar.

In comparative transmission studies it is frequently necessary to infect two segregated groups of mosquitoes from a common donor host. This can be accomplished easily by placing two of these cages side by side and using both legs of the chick, one inserted into each cage.

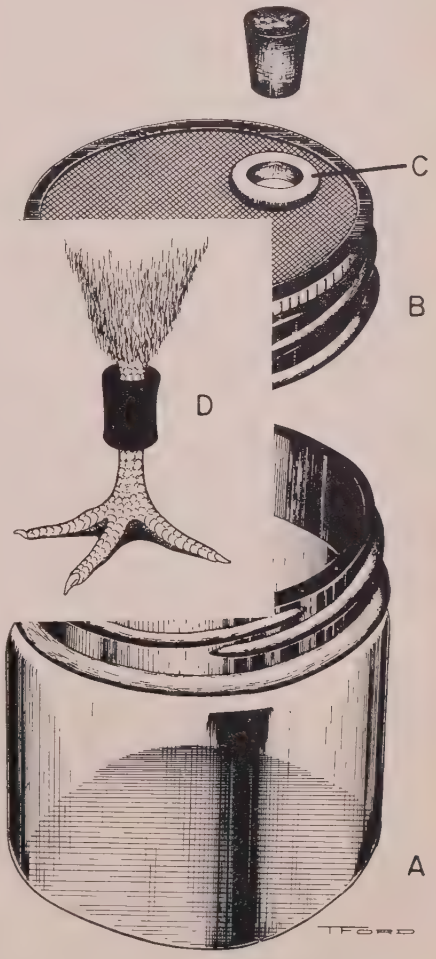

FIG. 1.—Exploded view of feeding cage. A, jar. B, top assembly. C, grommet. D, leg of chicken encased in rubber tubing.

ISOLATION OF EASTERN ENCEPHALITIS VIRUS FROM THE MOSQUITO *Culex restuans* COLLECTED IN NEW JERSEY DURING 1959

RICHARD O. HAYES,[1] LOUIS C. LAMOTTE,[2] LENDELL A. WHITE,[2] LESLIE D. BEADLE [3]

Eastern encephalitis (EE) virus previously has been isolated from several species of naturally infected mosquitoes: *Mansonia perturbans* (1), *Culiseta melanura* (2–5), *Anopheles crucians* (6, 7), *Aedes mitchellae* (7), *Culex salinarius* (5), *Culex taeniopus* (8), and *Culex nigropalpus* (8). The virus isolation from *Culex salinarius* was presumed to be due to recently ingested blood containing virus rather than from the mosquito tissue (5). Laboratory investigations have shown additional species to have potential as vectors of this virus (9). The isolation of EE virus from the mosquito *Culex restuans* Theobald collected in New Jersey during the encephalitis outbreak which occurred in the autumn of 1959 is herewith reported.

A pool consisting of 6 *C. restuans* collected in a New Jersey-type mosquito light trap at Woodbine, New Jersey was made by combining specimens obtained on the nights of October 2, 3, and 4, 1959. Following each night of collecting, the mosquitoes were hermetically sealed in glass vials and frozen on dry ice. The specimens, along with other mosquito pools, were shipped in the frozen state to the laboratory for testing. There was no evidence that any of the 6 *C. restuans* had recently taken a blood meal.

In the laboratory, the mosquitoes were ground in 3 ml. of a Hanks balanced salt solution containing 10 percent normal calf serum, 1000 units of penicillin per ml, and 500 micrograms of streptomycin per ml. The large particulate matter was allowed to settle out while the emulsion was held in an ice bath for about 1 hour. The supernatant fluid was inoculated intracerebrally into 5 mice, which were observed daily for signs of illness or death. No work with EE virus was in progress in the laboratory during the time when efforts were being made to isolate virus from these pools, nor was another isolation of EE accomplished from any other pool ground on the same day.

In the primary isolation attempt, 1 out of 5 mice died on the third day, and the other mice remained well. The brain of the dead mouse was harvested under aseptic conditions, ground in sterile Hanks BSS with antibiotics, and the supernatant fluid inoculated intracerebrally into 5 mice, and later into 6 additional mice. All 11 mice died on the second or third day. Reisolation was achieved from the original mosquito emulsion, and 2 of 6 mice died on the third and eighth days. An emulsion of the brains of these mice was passed intracerebrally into 6 mice, resulting in the death of all 6 on the second day. The virus concentration in a brain suspension was $10^{8.3}$ mouse IC LD_{50}. In a neutralization test in mice this virus was neutralized by EE hyperimmune rabbit serum, but not by WE hyperimmune or normal rabbit serum.

The epidemiologic implications of this virus isolation from *C. restuans* are considerable because of several facts. The residence of a confirmed human (2 years of age) case of EE was within 100 yards of the place of collection. *C. restuans* has been found to have good vector potential in laboratory studies (9). The geographic distribution (10) of the mosquito species coincides with that presently known for EE in the United States. The females of this species probably feed by preference on avian hosts, and they will also attack man (11). *C. restuans* could readily obtain virus infections from wild birds, considered to be the natural reservoirs of EE virus (12), and subsequently transmit them to other birds or mammals.

References and Notes

1. HOWITT, B. F., DODGE, H. R., BISHOP, L. K. and CORRIE, R. H. Science, 110:141 (1949).

2. CHAMBERLAIN, R. W., RUBIN, H., KISSLING, R. E. and EDISON, M. E. Proc. Soc. Exp. Biol. and Med. 77:396 (1951).

3. HOLDEN, P., MILLER, B. J. and JOBBINS, D. M. Proc. Soc. Exp. Biol. and Med. 87:457 (1954).

4. FEEMSTER, R. F., WHEELER, R. E., DANIELS, J. B., ROSE, H. D., KISSLING, R. E., HAYES, R. O., ALEXANDER, E. R. and MURRAY, W. A. New England J. Med. 259:107 (1958).

5. CHAMBERLAIN, R. W., SUDIA, W. D., BURBUTIS, P. P. and BOGUE, M. D. Mosquito News, 18:305 (1958).

6. KISSLING, R. E., CHAMBERLAIN, R. W., NELSON, D. B. and STAMM, D. D. Am. J. Hyg. 62: 233 (1955).

7. KARSTAD, L. H., FLETCHER, O. K., SPALATIN, J., ROBERTS, R. and HANSON, R. P. Science 125: 395 (1957).

8. DOWNS, W. G., AITKEN, T. H. G. and SPENCE, L. Science 130:1471 (1959).

9. CHAMBERLAIN, R. W., SIKES, R. K., NELSON, D. B. and SUDIA, W. D. Am. J. Hyg. 60:278 (1954).

10. CARPENTER, S. J. and LACASSE, W. J. Mosquitoes of North America. Univ. of California Press, Berkeley, 1955.

11. BARR, A. R. Univ. Minn. Tech. Bull. 228: 133 (1958).

12. BEADLE, L. D. Public Health Rpts. 74:84 (1959).

[1] Communicable Disease Center, Bureau of State Services Public Health Service, U. S. Department of Health, Education, and Welfare, Taunton, Massachusetts; [2] Greeley, Colorado; [3] Atlanta, Georgia

A Note on Collection of Heleidae and Other Biting Diptera in Suitable Condition for Dissection

D. H. Murphy, % Medical Research Council Laboratories, Fajara, Near Bathurst, Gambia

At present, it is standard technique in vector entomology, to age grade individuals on the basis of certain qualitative changes in the female genital tract. While for small scale work, hand catching of specimens is perfectly adequate, and for certain purposes essential, there are many investigations in which the use of less laborious collecting methods would be preferred, provided that they could be adapted to yield material in adequate condition for dissection. During the course of work on Heleidae in the Gambia (British West Africa), it was found that sticky trap material remained in good condition, and in the following notes are indicated the methods found satisfactory for preparing insects caught in this way for dissection, and for applying the principle to collecting at bait and light.

I. Sticky Traps

Heleid material has been collected in the Gambia by placing sticky traps covered with a proprietary tree-banding compound in the vicinity of cattle staked out in the open. Material so collected was soaked off the traps with kerosene which, unlike more volatile solvents such as benzene or Xylene, was found to prevent desiccation of the insects for up to twelve hours. After draining on filter paper, they could then be transferred to saline for dissection, and were found to be in excellent condition.

II. Baited Trap-huts

Trap huts of the type described by Bertram and McGregor (1956) in which mosquitoes are collected in ingress cages placed over the four windows of a baited, mobile hut, have been in regular use at this station for work with *Anopheles*. Traps in use for this purpose have been adapted to record heleids also by the simple device of pinning sticky traps to the inside of the hut (cf. Carpenter 1951). This method gives an indication of those species which, having penetrated the mosquito netting of the cages, rest in the vicinity of the bait either before or after biting. A single trap of 100 cm.^{2} surface area inside a 5 x 2 ft. goat-baited hut has collected up to 800 *Culicoides* in a single night. Where stable traps can be devoted exclusively to collecting heleids they can be made more efficient at low biting densities by using inwardly inclined baffles of transparent plastic sheet coated on the inner side with adhesive, placed across the window openings. Heleids enter to bite without difficulty, through the partially blocked windows, but when flying towards the light on leaving, are trapped on the sticky surface.

III. A Simple Light Trap

During the course of this work, it was found that conventional light trap material was usually dried out or otherwise unsuitable for dissection. It is therefore recommended that standard light traps be modified to collect insects into a non water pervious oil film, in order to prevent desiccation.

Satisfactory results were obtained by suspending a shallow, enamel dipping tray, containing a 5 mm. layer of liquid paraffin at a distance of about 20 cm. below any convenient size of electric light bulb, by means of a simple wire frame. A white enamel dish is preferable to glass as the reflection from the white surface attracts insects into the oil film. For field use, it has been found satisfactory to use a 6-volt bulb run from a heavy duty battery and in this case, the bulb should be suspended immediately above the oil surface, but preferably not actually immersed.

The liquid paraffin wets the insects immediately on contact, is nontoxic and protects the material completely from desiccation. Heleid material collected in this way was usually still found to have live tissues in the morning, with peristalsis of ovarian muscle and circulation of sperm in the spermatheca still clearly apparent.

For dissection, the insects were laid on filter paper until drained free of oil and then transferred directly to saline. The filter paper was found amply effective for removing the oil and no intermediate solvents were normally required. If desired, however, the draining can be speeded up by briefly washing the material in kerosene beforehand.

Material collected in this way has been found in all ways comparable with fresh material for age grading by ovarian dissection. Salivary gland dissections can also be performed, but since the insects tend to take oil into the crop, care must be taken to avoid compressing the abdomen if the dissection is not to be contaminated with oil globules. With experience this is no disadvantage.

Light trap material of Phlebotominae and Culicidae collected by the above technique, has also been examined and found in excellent condition for dissection.

These notes are published with the permission of Dr. I. A. McGregor, Director of the M.R.C. Laboratories in the Gambia. The author is also indebted to Prof. P. C. C. Garnham for his advice on the technique of salivary gland dissection.

References Cited

Bertram, D. S. and McGregor, I. A. 1956. Catches in the Gambia West Africa of *Anopheles gambiae* and *A. gambiae* var. *melas* Theobald in entrance traps of a baited portable wooden hut with special reference to the effect of wind direction. Bull. ent. Res. 47(4):669–681.

Carpenter, S. J. 1951. Studies of *Culicoides* in the Panama Canal Zone (Diptera, Heleidae). Mosq. News 11(4):202–208.

NOTE ON VARIATION IN LARVAE OF *Chaoborus* LICHT. (DIPTERA: CULICIDAE)

B. C. SMITH, Entomology Research Institute for Biological Control, Research Branch, Canada Department of Agriculture, Belleville, Ontario

Fourth instar larvae of *Chaoborus borealis* Cook, *C. americanus* (Joh.) and *C. nyblaei* (Zett.) collected at Churchill, Manitoba, in 1952 and 1953 by H. G. James (James and Smith, 1958) were identified by means of Cook's (1956) key. It was found that the shape of the prelabral appendages and the number of setae in the mandibular and anal fans of some specimens differed slightly from Cook's descriptions. Attempts were therefore made to define the differences using 150 fourth instar larvae of *C. borealis,* 78 of *C. americanus,* and 130 of *C. nyblaei.*

In *C. borealis* the ratio of length to maximum width of the prelabral appendages averaged 7.53 and ranged from 5.40 to 8.90; in *C. americanus* it averaged 2.73 and ranged from 2.40 to 3.90; and in *C. nyblaei* it averaged 2.85 and ranged from 2.00 to 4.90.

Four percent of the *C. borealis* larvae had 11 setae on one mandibular fan and 12 on the other, 31 percent had 12 on both fans, and 65 percent had 11 on both. Exuviae with 12 setae on both fans were of males and those with 11 setae on both fans were of females. One percent of *C. americanus* had 27 setae on both fans, three percent had 24, seven percent had 25 on one and 26 on the other, 44 percent had 26 on both, and 45 percent had 25 on both. Variation of this character in *C. nbylaei* was considerably greater than in the other two species. Two percent had 10 setae on one fan and 11 on the other, nine percent had 15 on one and 16 on the other, nine percent had 13 on both, 13 percent had 12 on one and 13 on the other, 15 percent had 14 on both and 52 percent had 13 on one and 14 on the other.

C. borealis had either 21 or 22 setae in the anal fan; 59 percent had 21 and 41 percent had 22. There was greater variation in *C. americanus;* one percent had 22, one percent 23, 15 percent 24, 75 percent 25, and eight percent 26. In this species, as in *C. nyblaei,* the larger larvae had the larger numbers of setae in the anal fan. In *C. nyblaei* there was one percent with 25 setae, two percent with 26, two percent with 27, three percent with 28, one percent with 29, three percent with 31, 45 percent with 32, four percent with 33, 33 percent with 34, three percent with 35, one percent with 36, and two percent with 37.

The present observations on the larvae of the three species, with Cook's observations in brackets, are summarized in the accompanying table.

SUMMARY

This paper describes variations in last-instar larvae of *Chaoborus borealis* Cook, *C. americanus* (Joh.) and *C. nyblaei* (Zett.) from Churchill, Manitoba.

References

COOK, E. F. 1956. The Nearctic Chaoborinae. Univ. Minnesota Agr. Exp. Sta. Tech. Bull. 218.

JAMES, H. G., and SMITH, B. C. 1958. Observations on three species of *Chaoborus* Licht. (Diptera: Culicidae) at Churchill, Manitoba. Mosquito News 18:242–248.

Species	Prelabral appendage ratio	Number of setae in mandibular fan	Number of setae in anal fan
C. borealis	5.40–8.90 (7.00–7.33)	11–12, (11–12)	21–22, (21–22)
C. americanus	2.40–3.90 (less than 2.5)	24–27, (22–29)	22–26, (23–26)
C. nyblaei	2.00–4.90 (4.5, 3 in Canadian specimens)	10–16, (13–20)	25–37, (24–33)

ASSOCIATION NEWS

MINUTES OF THE 16th ANNUAL MEETING OF THE AMERICAN MOSQUITO CONTROL ASSOCIATION

Boston, Massachusetts, March 27–30, 1960

RECORDED AND REPORTED BY A. F. GEIB

A meeting of the Board of Directors of the American Mosquito Control Association was convened at the Somerset Hotel, Boston, Massachussets, 10:00 a.m., March 27, 1960 by Association President Archie Hess. Present were D. M. Jobbins, President-elect; W. E. Bickley, Vice-President; T. G. Raley, Executive Secretary; L. W. Smith, Treasurer; R. L. Vannote, National Advisor; A. F. Geib, Recording Secretary; J. M. Hirst, Past President; Regional Directors: B. Hocking, Canada; R. W. Bunn, S. E. Central; J. A. Mulrennan, S. Atlantic; C. F. Scheel, N. E. Central; O. P. Breland, S. W. Central; J. E. Graham, N. Central; D. Grant, S. Pacific.

Absent were: Regional Directors L. S. Miller, N. Pacific; Vernon Conant, N. Atlantic; L. Vargas, Mexico, Central and South America.

Committeemen and others present: A. Lindquist, A. W. A. Brown, R. Dorer, F. Creadon, B. Brockway, C. Robinson, G. Collett, D. Collins, E. Thurman, R. Armstrong, C. Williamson, E. Davis, G. J. Foyle, J. Nelson, F. Stutz, T. Mulhern.

President Hess called the meeting to order with the roll call.

It was moved by L. W. Smith that the minutes of the 15th Annual Meeting of the AMCA be approved as published in the June 1959 issue of *Mosquito News;* seconded by C. F. Scheel; carried.

President Hess appointed the following Resolutions Committee: D. Grant, Chairman; R. Armstrong and A. Lindquist.

The President submitted his Annual Report. (*Attachment* #1.). T. G. Raley moved acceptance; seconded by D. Grant; carried.

G. C. McFarland announced plans and arrangements were underway for the 17th Annual AMCA meeting to be held jointly with the California Mosquito Control Association, Disneyland, California, January 30, 31, and February 1 and 2, 1961.

President Hess called for the report from the Nominating Committee Chairman. Hirst reported that the actions of the Committee and Nominations for offices had been published in the December 1959 issue of *Mosquito News.*

Report of the Treasurer, L. W. Smith. (*Attachment* #2.) He noted the Association had done exceptionally well during 1959, concluding the year with a net increase of approximately $3,000.00. *Mosquito News* Editor, D. Collins, reviewed financial details of publication of the *News.* Lindquist moved acceptance of the Treasurer's report; seconded by Jobbins; carried.

Report of Finance Committee, C. Scheel, Chairman. (*Attachment* #3.) Grant commended and moved acceptance of report; seconded by Jobbins; carried. Discussion was held concerning recommendations contained in the report. President Hess appointed the following committee to study the Finance Committee recommendations and present their considerations to the incoming Board on Wednesday: Chairman, Jobbins; L. Smith, C. Scheel, T. Raley, F. Creadon, E. Thurman and C. Williamson.

C. Scheel reviewed the 1959 budget and expenditures. He recommended that a vote of thanks be given all those who contributed to the economic gain accrued during 1959. He then submitted the proposed budget for the calendar year 1960.

Hess asked for acceptance as a report and requested that the final budget be acted upon at a later meeting of the Board. It was so moved by Grant; seconded by Lindquist; carried.

The meeting recessed at 12:00 p.m., to reconvene at 1:15 p.m.

REPORT FROM THE EDITOR OF *Mosquito News* AND STAFF; Don Collins. (*Attachment* #4.) Hirst moved acceptance of report; seconded by Jobbins; carried.

REPORT FROM STANDING COMMITTEE ON PUBLICATION OF *Mosquito News;* Ken Knight, Chairman. (*Attachment* #5.) In the absence of the Committee Chairman, the report was read by Hess. Scheel moved acceptance of the report; seconded by Lindquist; carried. The following recommendations contained in the report were considered:

1. An Editorial Board for *Mosquito News.* Following discussion, it was concurred that the Standing Committee on Publication of *Mosquito News* could act as an Editorial Board, without the need to amend the by-laws; also that appointment of members to this committee would be in accord with the recommendations.
2. Recommends discontinuance of the practice of turning in manuscripts at the Annual Meeting. Bickley moved that a notice be appropriately placed in *Mosquito News* requesting that henceforth papers presented at the Annual Meeting, with accompanying letter of transmittal, be *mailed* to the Editor in *proper form for publication;* seconded by Hirst; carried.
3. Publishing date on which manuscripts are accepted.

Grant moved that this recommendation be adopted, seconded by Jobbins; Bickley moved the motion be tabled; seconded by Hirst; carried.

REPORT FROM PROGRAM CHAIRMAN, W. E. Bickley. Noted that in developing the program there had been two meetings of the President-elect and the Vice President, and much correspondence. The program as developed emphasized five general areas of interest:

1. Eastern Encephalitis.
2. Residue Problems.
3. Flight Range.
4. Mosquito Control Operations.
5. Insect Resistance.

REPORT OF COMMITTEE ON SALES OF ADVERTISING IN *Mosquito News;* F. Creadon, Chairman. (*Attachment* #6.) The report was accepted by acclaim.

REPORT OF COMMITTEE ON GOOD NEIGHBOR CLUB; E. Thurman, Chairman. (*Attachment* #7.) Accepted by acclaim.

REPORT OF LOCAL ARRANGEMENTS COMMITTEE CHAIRMAN, Bob Armstrong. The Association is indebted to the Plymouth Plantation for their aid in printing the program and permission to use their cut on the back of the program cover. The report was accepted by acclaim.

REPORT OF BUSINESS MANAGER OF MISCELLANEOUS PUBLICATIONS; C. Williamson, Business Manager. (*Attachment* #8.) Williamson noted that sales of Miscellaneous Publications has declined considerably. He recommended:

1. Bulletin #1, now out of print, be rewritten. Bulletin #2, with 200 to 300 copies on hand, seemed an adequate supply. Bulletin #3 with 60–70 copies on hand seemed an adequate supply.
2. Office of Business Manager be consolidated with that of Executive Secretary or Treasurer.
3. Uncollectible bills be written off.

Jobbins moved acceptance of report; seconded by Smith; carried.

REPORT OF MISCELLANEOUS PUBLICATIONS COMMITTEE, Howard Greenfield, Chairman. (*Attachment* #9.) Hess read the report in the absence of Greenfield. Hirst moved acceptance; seconded by Bickley; carried.

REPORT OF MEMBERSHIP COMMITTEE, B. Brockway, Chairman. (*Attachment* #10.) Hess and Raley both commended committee activities in the past year. Following discussion it was concurred that the

new Committee be instructed by the incoming President to consider the time for dropping delinquent members from the *Mosquito News* mailing list. Hirst moved acceptance of report; seconded by Mulrennan; carried.

REPORT ON PUBLIC RELATIONS, R. E. Dorer, Chairman. (*Attachment* #11.) Raley moved acceptance; seconded by Hirst; carried.

REPORT OF NATIONAL ADVISOR, R. L. Vannote. (*Attachment* #12.) Grant moved acceptance; seconded by Jobbins; carried.

REPORT OF RESEARCH AND DEVELOPMENT COMMITTEE, A. Brown, Chairman. (*Attachment* #13.) Grant moved acceptance of report; seconded by Mulrennan; carried.

REPORT FROM COMMITTEE ON BYLAWS, R. Peters, Chairman. Hess read a letter from Peters noting there were no recommendations or changes for the Bylaws.

LEGISLATIVE COMMITTEE REPORT, C. Robinson, Chairman. (*Attachment* #14.) Bickley moved acceptance; seconded by Geib; carried.

REPORT OF EXECUTIVE SECRETARY, T. Raley.

1. Raley noted that Board approval of new members was in order. Smith moved that all new members be approved; seconded by Bickley; carried.
2. Reported receipt of numerous requests for information regarding Association purposes and objectives and data on *Mosquito News*.
3. Noted that an invitation had been received from Texas to hold the 1962 AMCA meeting at Galveston.
4. Called attention of AMCA members that the Office of Executive Secretary would supply on demand a list of membership and subscribers for any State or Region.
5. Asked for comments concerning the practice of charging for membership lists when requested by organized agencies and commercial firms. Jobbins moved indorsement of this practice; seconded by Mulrennan; carried.

President Hess commended the Executive Secretary, all officers, committees, and members for the fine job done this past year and thanked all for their help during his term of office.

The meeting adjourned at 5:00 p.m.

GENERAL BUSINESS MEETING—TUESDAY, MARCH 29, 1960, 3:30 P.M.

The meeting was called to order by President Hess, who reviewed the highlights and business activities of the Association during the past year as shown in his annual report, and the minutes of the meetings.

President Hess reported that a number of applications for Association membership had been received at these meetings. It was moved by Bickley, seconded by Breland that all new membership applications be approved; carried unanimously.

President Hess called for the report of the Nominating Committee. Chairman Hirst read the names of the nominees for officers of the Association as listed in the December 1959 issue of *Mosquito News*.

For President, D. M. Jobbins, elected unanimously.

For President-elect, Dr. W. E. Bickley, elected unanimously.

For office of Vice-President, there were four nominees: Brockway, Buzicky, Geib and Micks. Members of the Nominating Committee were appointed to serve as an ad hoc election committee to distribute ballots and serve as tellers, with Bob Vannote as chief teller and A. W. A. Brown as recorder. Ballots were distributed, marked, collected, tallied and recorded by the ad hoc committee. There were 139 votes cast for the office of Vice-President, with one being rejected as improperly marked:

Brockway	17 votes
Buzicky	7 votes
Geib	67 votes
Micks	47 votes

With no candidate receiving a majority, ballots were again marked for one of the two candidates receiving the greatest number of votes on the first ballot. Votes on the second ballot numbered 118 for the office of Vice-President, with the results: Geib elected Vice-President with 71 votes; 47 votes cast for Micks.

Majority votes were cast for the following offices as follows:

Recording Secretary, E. Thurman, 71 votes.

Regional Directors, South Atlantic Region, J. A. Mulrennan, 103 votes; Northwest Central Region, J. E. Graham, 69 votes; Southwest Central Region, O. P. Breland, 112 votes; North Pacific Region, C. M. Gjullin, 93 votes; Mexico, Central and South America Region, Dr. L. Vargas, 76 votes.

President Hess requested a REPORT FROM THE RESOLUTIONS COMMITTEE, which was read by Chairman D. Grant. (*Attachment* #15.) Mulrennan moved acceptance of report; seconded by Scheel; carried.

The President asked for discussion considering a proposal to increase membership dues. Following discussion, McFarland moved that a vote for or against proposal be taken by a show of hands; seconded by Rogers; vote showed proposal overwhelmingly defeated.

Helen Sollers requested that wherever possible, references be included with articles submitted for reviews and abstracts.

Don Collins called attention to the need for more Scientific Notes as well as News and Notes in *Mosquito News*.

Dr. Meyers reported that participants in the Trustees' meeting were pleased with results. General consensus was that the Trustees' meeting:

1. Should be held again.
2. Should be informal.
3. At least some prepared questions be submitted.
4. A Moderator should be chosen, who would direct meeting.
5. Attendance be limited to Trustees.

Past President Dorer escorted Dan Jobbins to the rostrum where he accepted the President's gavel from Archie Hess, outgoing President. Jobbins noted that in his experience there were a greater diversity of specialized interests in the AMCA than in any other group with which he was associated.

Among objectives for the coming year, he hopes to work toward:

1. Achieving balance among the various interests and individuals of the Association.
2. Accomplish consolidation of some of the Association's activities.
3. Further the interests and purposes of the Association with the aid of committee and membership support.

Past President Dorer escorted President-elect Bickley to the rostrum for introduction, and then, in turn, Vice-President Geib.

The meeting was adjourned at 5:00 p.m.

BUSINESS MEETING—1960 BOARD OF DIRECTORS

Wednesday, March 30, 1960, 7:00 P.M.

RECORDED AND REPORTED BY ERNESTINE THURMAN

Present: Jobbins, Bickley, Geib, Raley, Smith, Vannote, Bunn, Gjullin, Breland, Scheel, Hirst, Graham, Hess, McDuffie, Fisher, Brockway, McFarland, Thurman, Collett, LaBrecque, Armstrong and Collins.

Absent: Hocking, Grant, Mulrennan, Conant and Vargas.

President Jobbins opened the meeting and read a letter from Vernon Conant, Director North Atlantic Region, requesting that Mr. Wm. A. Fisher be allowed to represent him in his absence. Bickley moved acceptance of Conant's request, seconded by Scheel; carried.

President Jobbins submitted a suggested list of committees for consideration and appointments. (*Attachment* #16.)

Hess moved that all Committee Chair-

men be approved as shown on the list, seconded by Smith; carried.

Hirst and Bunn both questioned need for continuing the Research and Development Committee, pointing out that its purpose had been served and it could be reactivated at a later date if needed.

Hess restated motion—moved that all Committee Chairmen be appointed as shown in *Attachment* #16, seconded by Smith; carried, with Hirst and Bunn voting "no."

Raley moved that A. W. A. Brown act as Chairman for the Research and Development Committee, seconded by Bickley; carried.

Hess moved that the Standing Committee on Finance be continued as in the past; Scheel Chairman, with the Chairman responsible for appointing Committee members, seconded by Bickley; carried.

Raley moved that Francis Creadon be appointed Chairman of the Committee on Sale of Advertising Space and that he choose his Committee members; seconded by Hess; carried.

Raley moved that Wm. Thom be appointed Assistant Treasurer, seconded by Bickley; carried.

Hess commended new President, Jobbins, for having committees and appointments prepared in time for consideration at this meeting.

President Jobbins noted that Don Collins would be attending the 11th International Congress of Entomologists meetings at Vienna, Austria, as an official delegate of the AMCA at no cost to the Association. Following discussion of official delegates of the Association attending these meetings, Hess moved that the AMCA appropriate $600 of Association money, to be added to the $1,500 grant received by the Association; these funds to be used to pay the transportation costs of three members as Official Delegates to the meetings; transportation costs of delegates would cover round trip, home base to home base, with any balance remaining after paying transportation costs to be divided evenly among the three delegates to help on their expenses, seconded by Bunn; a show of hands was requested by President Jobbins—there were 11 ayes and 1 no vote by Hirst.

President Hess had earlier canvassed Board Members by mail to obtain a census of who might be logical as Official Delegate of the AMCA. Potential delegates chosen from this balloting were: Raley, Jobbins, Bickley, Hess, Smith, McDuffie, Morrill, Provost, Sollers and Peters. Among these, Hess and McDuffie requested that they not be considered. Hess requested that secret ballots be cast to determine who would be the three Official Delegates chosen from the approved list, to be sent at the expense of the AMCA.

Ballots were prepared, recorded and tallied. The results were: three members receiving most votes and thus elected to represent the AMCA—Raley, Jobbins and Smith, with Bickley first alternate and Peters second alternate.

Bunn noted that Ernestine Thurman would be attending the 11th International Congress of Entomologists meetings and moved that an Official letter be written designating her as an Official Delegate of the AMCA, seconded by Hess; carried.

Raley moved that $200 be allowed Don Collins to aid in defraying travel expenses as an Official Delegate to the 11th International Congress of Entomologists meetings, seconded by Breland; carried.

McFarland officially invited the AMCA to meet jointly with the California Mosquito Control Association at Disneyland, California; January 30, 31, February 1 and 2, 1961. Raley moved the invitation be accepted, seconded by Hess; carried.

Raley moved acceptance of the Gulf Coast Mosquito Control Association (Texas) invitation to meet jointly with the AMCA in 1962, and the New Jersey Mosquito Extermination Association's invitation to meet with it in 1963, seconded by Breland; carried.

Hess moved that the 1959 Proceedings be published in *Mosquito News* with due recognition on the cover to the Northeast Mosquito Control Association, seconded by Bickley; carried.

Raley moved that the President of the AMCA write a letter of appreciation and

thanks to Don Collins' immediate superior for the wonderful job done by him and his staff in editing and publishing *Mosquito News,* seconded by Hess; carried.

Raley reported that the History of AMCA would be ready for publication in *Mosquito News,* probably in the September or December issue.

President Jobbins called for a REPORT FROM THE SPECIAL COMMITTEE (appointed at the Sunday Board Meeting) TO CONSIDER CONSOLIDATION OF BUSINESS ACTIVITIES. Vannote reported for Jobbins. (*Attachment* #17.) Hess moved approval of Committee's recommendations, seconded by Bunn; carried.

Bunn moved that necessary action be taken to make proper investment of surplus Association funds, seconded by Hess; carried.

Bickley moved that an Association membership list be published in *Mosquito News* at the earliest date possible, seconded by Breland; carried.

ATTACHMENT #1

PRESIDENT'S ANNUAL REPORT—MARCH 27, 1960

Four communications were transmitted to the Board of Directors and the President's Advisory Committee requesting approval and advice on various matters concerning the Association. In all of these matters except No. 4, the President has refrained from voting or taking sides. The principal items considered were as follows:

1. *Appointments of Committees which were not made at the meeting of the Board of Directors at Salt Lake City on April 15, 1959.* Approved.
2. *Reprinting covers of June 1959 issue of* Mosquito News *for use by Chairman of Membership Committee in soliciting new members.* Approved.
3. *Exhibiting Rollie Dorer's "AMCA Mosquito" at the Entomology meetings in Detroit and the AMCA meetings in Boston.* Approved.
4. *Appointment of a committee on amalgamation of AMCA with State associations.* Not approved. (Board—6 for and 6 against; President—against.)
5. *Increase in annual membership dues.* Eight of 12 members of the Board and 4 of 7 members of the Advisory Committee recommended an increase, but most of them favored a small increase. Acting in accordance with this recommendation, the President on November 24, 1959, submitted to the Executive Secretary and the Chairman of the Bylaws Committee a proposal that our bylaws be amended to increase the annual dues to $6.00. This proposal is to be voted upon at the final business meeting on March 29, 1960. In accordance with Article XI of our bylaws, it will require a two-thirds vote for approval.
6. *Change in name of Association and Mosquito News.* Nine of 12 Board members voted against, and 5 of 8 members of Advisory Committee voted against. Therefore, no further action was taken on this matter.
7. *Appointment of International Advisor.* Seven of 12 members of the Board and 4 of 7 members of the Advisory Committee favored the appointment, and the majority preferred separate advisors for the New and Old World. Don Pletsch was the unanimous choice for New World Advisor and Tony Brown, Don Micks, and Louis Williams were tied for Old World Advisor. Since final action of the Board was not received until December, the appointments were deferred. It is recommended, however, that (1) the incoming President appoint Don Pletsch as the International Advisor for the New World and a member of his own choice as International Advisor for the Old World; (2) that he submit these appointments for approval at the Board of Directors' meeting on Wednesday evening, March 30, 1960.

8. *AMCA Representative at International Congress of Entomology, Vienna, August, 1960.* The Board and the Advisory Committee voted unanimously for Don Collins to be our representative. However, Don's application to the Entomological Society of America was also approved, as were four other members of our Association (H. C. Barnett, D. W. Micks, G. B. Craig, and A. O. Lea). We, therefore, requested the Board to suggest additional names for the AMCA application (which has subsequently been approved for $1,500 effective May 1, 1960). Listed in order of priority are the 10 individuals who received the highest number of votes together with the total voting points each received: 1—T. G. Raley (27); 2—Manley Jobbins (25); 3—W. E. Bickley (23); 4—A. D. Hess (21); 5—Lester W. Smith (18); 6—W. C. McDuffie (17); 7—Austin W. Morrill (15); 8—Maurice Provost (11); 9—Helen Sollers (10); 10—Richard Peters (10). The President did not exercise his prerogative to vote on this matter, and hereby withdraws his own name from consideration. It is recommended that the incoming President submit the names of T. G. Raley and one other of the above individuals for approval at the Board of Directors' meeting on Wednesday, March 30, 1960.

Other recommendations which have been received from the Board and the Advisory Committee include the following:

1. *Ways for Obtaining Additional Financial Assistance.* (a) Intensified drive for new members covering a wider area of specialization; (b) direct contributions from commercial sponsors and more participation of commercial firms in Association activities; (c) more advertising covering a wider variety of products; (d) grants from philanthropic organizations, Ford Foundation, Rockefeller, etc.; (e) obtain more support from state and local abatement organizations.
2. *Promoting Sale of AMCA Pins.* (a) Offer to all new members or make part of new membership fee; (b) sales campaign at annual meeting; (c) have Regional Directors sell them; and (d) let the ladies sell them—they've been pinning things on men from birth to grave!
3. *Miscellaneous.* (a) Require guarantee of $1,000 to AMCA from sponsors of annual meeting and split profits above that amount; (b) Develop simpler and less costly format for *Mosquito News;* (c) Drop the title of "Dr." for individuals with Ph.D. on our program; (d) *Mosquito News* should exchange advertising space with other journals and carry features on individuals and institutions; (e) Establish a central business office; (f) Establish mail balloting for election of officers; (g) Give additional remuneration to the Executive Secretary; (h) Provide honorary and paid life memberships; and (i) Have a popular lecture at each annual meeting.

At the meeting of the Board of Directors in Salt Lake City on April 15, 1960, it was recommended that the annual meeting be held in southern California in 1961, in Galveston in 1962, and in New Jersey in 1963. Under date of March 4, 1960, a letter has been received from Price Daniel, Governor of Texas, inviting the Association to meet in Galveston in 1962.

During his year of tenure the President spent $20.64 for postage, $7.32 for telephone calls, and $1.40 for a light on the speaker's stand, making a total of $29.36. This leaves a debit of only $3.67 over the $25.69 carried over from the $100.00 allocated for the 1959 program. When the President is reimbursed the $3.67 he will add $1.33 to it and sponsor another Good Neighbor!

Appreciation is expressed to the Board of Directors, the President's Advisory Committee, officers of the Association, and the various Committee Chairmen and mem-

bers for their cooperation and assistance during the past year. It is recommended that the incoming President again appoint all Past-Presidents not on the Board to serve as a President's Advisory Committee.

—A. D. HESS, *President*

ATTACHMENT #2

AMERICAN MOSQUITO CONTROL ASSOCIATION
METUCHEN, NEW JERSEY

SUMMARY OF CASH RECEIPTS AND DISBURSEMENTS
TREASURER'S ACCOUNT, NOVEMBER 27, 1958 TO DECEMBER 31, 1959

RECEIPTS	General Account		Special Publications	
Balance on deposit—November 27, 1958		$6,034.02		$1,927.30
Dues and subscriptions	$7,453.23			
Advertising	3,711.23			
Back issues	208.00			
Reprints	1,179.36			
Good Neighbor Club	590.00			
Bulletins	6.00			
C. T. Williamson—transfer of funds	0			500.00
Mailing lists	145.00			
Unidentified deposits	20.00			
Transfer of funds and exchanges (contra)	20.00			150.00
Other receipts—postage refund	3.00			
Exhibits Committee—15th Annual Meeting	1,350.00			
Sale of pins	80.50	14,766.32		
		20,800.34		2,577.30
DISBURSEMENTS				
Printing of *Mosquito News*, reprints and mailing charges	$9,341.69			
Office supplies, expenses, etc.	303.93			
Postage	451.90			
Fidelity bond	5.00			
Traveling expenses	500.00			
Exhibits—materials and expenses	325.26			
Convention expense—1959	100.00			
Examination of Treasurer's records	75.00			
Refund to subscribers	10.00			
Bank charges	2.77			
Transfer of funds to general account (contra)			$150.00	
Exchanges (contra)	20.00	11,135.55		150.00
Balance—December 31, 1959 (on deposit—Commonwealth Bank of Metuchen, Metuchen, New Jersey)		$9,664.79		$2,427.30

—Submitted by LESTER W. SMITH, *Treasurer*
Audited by Nathan Lipman, C.P.A.

ATTACHMENT #3

Report of the Standing Committee on Finance

March 27–30, 1960

The income levels as set up by the Finance Committee in its 1959 budget were achieved with gratifying results. Not alone were our receipts much higher than anticipated but disbursements were below allotments. Those responsible for this superb accomplishment are deserving of a hearty vote of thanks and gratitude from the Association.

Our financial position is highly adequate for current purposes and provides possibilities of studying such measures of expansion and development as may appear feasible and timely to the board.

The Finance Committee is hopeful of being able to contribute constructively to these deliberations and also enlists wholehearted membership support in any of these efforts.

—C. F. Scheel

ATTACHMENT #3A

Supplement to Report of Finance Committee

One of the recognized functions of the Standing Committee on Finance is that of giving thought to developing ways and means of providing operating revenue to the association. This committee, however, as mentioned in previous annual reports, felt that they would be extremely remiss in such deliberations if they failed to consider measures which in their opinion might, through proper financial support, lead to a further development in the growth and aspirations of the Association. In accord with this view the following is being submitted to the Board members for their consideration.

The importance of material developed and broadcast by our many talented association members is common knowledge and causes one to look eagerly toward new horizons of enlightenment and usefulness. Much has been said in the past of the real need for the association as a medium of importance in the field of vector control. A desire to make its influence of greater national and international value has been constantly on the minds of many of our good brothers. Last year, for instance, at the Salt Lake City meeting the Research and Development Committee presented a rather sagacious report outlining among other things the pressing need for satisfactory solutions to control-worker problems. At the same meeting Archie Hess gave his views on the need to recognize expanding interests in the association if we are to continue our healthy condition of growth and progress. These are only typical of the many challenges constantly being laid at our doorstep.

To what extent these new horizons may or should become a part of association consideration are of vital concern to the Finance Committee. While this committee feels that we should never under any circumstances accept the status quo as a fixed working level it is nevertheless of the opinion that a definite relationship exists between any financing program and the successful expansion of Association interests—they must grow together.

Since the AMCA was organized as a non-profit organization it would seem more or less mandatory not to embark upon any fund producing plans beyond those necessary properly to support authorized activities including, of course,

reasonable margins for contingencies. As the demand for desirable project material may become evident, so also does the toll for promotion mount more or less proportionately whether it be gratuitous or otherwise. Regardless of how this effort is provided, it appears to this committee as sound practice to assure supporting financing or gratuitous service well in advance of inaugurating any expense project, thus avoiding the possibility of deficit spending.

As an association we have been extremely fortunate over the years in having efficient and constructive assistance contributed in unlimited measure by the treasurer, executive secretary, editor, advertising manager and others. While this effort had rather simple beginnings, as in all operations of this character, it by nature has become progressively more involved, not alone to the individual concerned but also something of a growing imposition upon the district or employer who has graciously but perhaps unintentionally permitted such chores to build up to extra-curricular activities of sizeable proportions. All of which gives rise to some speculation on ways and means of more independently providing for this phase of our activity. Consolidation of some of the increased routine detail of the treasurer and executive secretary's office and employing a full time clerk has been discussed and seems worthy of further consideration. In due time the merging of other routine activities would naturally follow, leading ultimately to the possibility of engaging the services of a full time office manager who would be qualified to administer our broadening interests and services. Whether full time skilled clerical experience should be hired or whether it would be preferable to engage part time help at a more attractive rate are minor details to be resolved. Possibly any step in this direction should be limited for the present to some occasional outside help local to both offices.

All of these projects, particularly those relating to our more important expanding interests, should of course not be instituted hastily but rather individually explored for net values and required financial and procedural support before adoption.

As a committee we feel that anything but adequate financial preparation in these efforts would tend to curb needed flexibility in properly developing any plan and possibly stifle early accomplishment which could lead to the undesirable practice of deficit spending by dipping into reserves.

The matter of sending delegates to the Vienna convention, which has already been discussed, or meeting other special contingencies, further cuts into our reserves. However, reserves are purposely set up to support such contingencies and not for the purpose of carrying programmed expenditures. It would appear that a modest *increase in membership dues* would readily supply any needed income for full time clerical help as mentioned above and at the same time should not be considered too severe by the constituency when it sincerely reflects upon the value and character of material now received from the association. Higher revenue from increased dues is of course only one of several sources from which support of this and other ventures was expected to emerge. As the need presented itself a study of the *Mosquito News* format, a more intensive drive for *advertising* including the soliciting of non-member suppliers, more activity toward *sustaining memberships,* budget appropriation for educational purposes from all districts where possible and a new approach to the matter of securing *grants-in-aid* on specific projects are a few of the other potentials. It must be remembered that some of the present bank balance was accumulated through the sale of various bulletins. Such bulletins might reasonably be issued to each member without cost as one of the services to which a properly adjusted dues level may justly entitle them. As it now stands, the sale of

bulletins has never developed into a very lucrative steady source of income, but has deteriorated into an inactive stockpile of valuable material resting on our shelves. So our income must, over the long pull, be implemented by more substantial steady sources of revenue as genuine fixed needs become evident.

Currently we have a bank balance of approximately $12,000 of which at least half may properly be invested in the *purchase of acceptable securities,* leaving the balance for a *contingency fund.* The practicability of disbursing part of this surplus for some specific project now and deciding to operate at a lower balance level is also worthy of early consideration. However, it would appear that rather than not aggresively pursuing every possible source of income, we should at all times have in our docket projects waiting for needed financial assistance and exploitation.

All of the above discussion pertaining to expanded association interests, consolidation of certain office routines, absorbing portions of the gratuitous effort, establishing reasonable fiscal balance levels and other kindred matters such as the possibility of *carrying the planning and expense of the annual meetings* have for some time been of major interest to the Finance Committee.

It is our considered opinion that integrating the functions of the *Finance Committee* with those of the *Ways and Means Committee,* thus forming a Finance and Policy Council, holds considerable promise of enhancing the proper dispatch of any such matters. It would be the function of this committee, as we see it, to entertain or initiate and evaluate the merits of any new undertaking, giving due consideration to required financial and procedural needs. It would present concrete recommendations to the Board of Directors well in advance of the yearly meeting and would also be in a much better position to prepare an annual budget on a sounder basis.

Such a Council might be made up of at least the following: the immediate past-president, who would have fresh knowledge of weaknesses of unfinished development requiring continued attention, the executive secretary who is constantly in touch with all aspects of the operation, a member of the existing finance committee, the president elect and the new president who would act as chairman. The Finance Committee strongly feels that an arrangement of this character would help tremendously in crystallizing all points of view, go far toward minimizing under-developed conclusions and give a much needed impetus to disposing of good intentions frequently carried over from year to year.

The committee trusts that each member of the Board may view the potential merits of such a proposal with favor.

ATTACHMENT #5

Report of the 1959–60 Standing Committee on Publication of *Mosquito News*

1. The full membership of this Committee was not established until rather late in the year. However, the Chairman, and later the full Committee, was available to Editor D. L. Collins for consultation and assistance throughout the year. In one case referee assistance was requested and given by the Chairman.

2. It is sincerely believed that a publication of the high caliber and wide acceptance typical of *Mosquito News* should have an editorial board. It is only infrequently that the Editor has need to refer a problem to an advisory group, but when need arises for rejecting or modifying a controversial manuscript, such a board can

serve a valuable purpose. Furthermore, by establishing a board, of say five individuals, by Executive or Board of Directors appointment, the situation would not again arise of having several months elapse before a full Committee is available for service. Additionally, this would give members sufficient tenure to learn something of the duties which they are supposed to perform. Each member could serve a five year term with one old member leaving and one new member joining the editorial board each year. The Chairmanship could rotate each year to the oldest member in point of service. In order to represent all segments of the membership of the Association, the board could have the following membership: One member each from Federal Service (USDA, USPHS, and Military), from State Service (Experiment Stations, State Boards of Health), from industry, from abatement districts (county or smaller taxable units), and from the academic world. A copy of the Constitution of the American Mosquito Control Association is not at hand but it is presumed that the establishment of an editorial board would require a constitutional amendment. At any rate, such an agency should have constitutional recognition.

3. It has been pointed out by one of our members that the practice of turning in manuscripts at the annual meetings is, for several reasons, a poor one. With this, we concur and believe that it should be discontinued. For one thing, it is possible for a manuscript to get lost some place in the confusion of the meeting. Secondly, a procedure of accepting only mailed manuscripts might automatically eliminate certain papers that could just as well be left unpublished. Finally, such a change in procedure would relieve our editor of an unnecessary burden at annual meetings.

4. It is believed that the practice of publishing the date on which each paper is accepted for publication (such, as for example, is done by the Entomological Society of America) is a good practice.

5. *Recommendations.* It is recommended that:

a. Proceedings be initated to establish an Editorial Board for *Mosquito News*. A suggested structure for such a board is presented in paragraph 2. At this point, it is desired to interject one word of caution. Although we believe strongly that a constitutionally-recognized editorial board is essential, such a board must always stand in a secondary position to the Editor. In other words, the board is his to use as much or as little as he desires. The Editorial Boards of the E.S.A. operate in this manner and are most successful. Furthermore, it is believed politic that the Editor should be consulted in the selection of members for the Board, since he is the one who must work with them.

b. The procedure of accepting manuscripts at the annual meetings be discontinued.

c. The procedure be adopted of publishing the date of acceptance of each manuscript.

6. It is desired to extend to the Editor and to his assistant editors our sincerest congratulations for the most excellent way in which they continue to fulfill their responsibilities. Due to their efforts, the Association has a publication of which we can all be proud in the fullest sense of the word.

Respectfully submitted,
—RICHARD F. DARSIE, JR.
RICHARD B. EADS
HARRY D. PRATT
ANDREW J. ROGERS
E. CHESTER ROBINSON
KENNETH L. KNIGHT,
Chairman

ATTACHMENT #4

EDITOR'S REPORT

Statistics on Volumes 18 and 19, *Mosquito News*

Issue	No. Printed		No. Pages		Cost *	
	Vol. 18	Vol. 19	Vol. 18	Vol. 19	Vol. 18	Vol. 19
March	1650	1650	68	64	$1,774.43	$1,591.77
June	1650	1650	152	112	3,278.85	2,284.34
September	1650	1650	104	100	2,260.16	2,226.06
December	1650	1700	92	96	2,301.91	2,259.00
Totals	6600	6650	416	373	$9,615.35	$8,361.17

* Cost of Vol. 18 includes postage; Vol. 19 was mailed under second class rate and postage is billed separately. Mailing charges for Vol. 19 amounted to $194.46.

	No. Pages	
	Vol. 18	Vol. 19
Proceedings	103½	69
Articles	144½	131½
Operational and Scientific Notes	5½	9
Editorial	1½	3½
Association News	29½	25
News and Notes	17	15½
Reviews and Abstracts	6	4½
Bibliography	34½	35
Advertising	68	76
Miscellaneous	6	3
Total	416	372

Referring to the statistics on the several issues of each volume, it is pointed out that for the purpose of presenting the information from the editorial office, a consideration on the basis of the four issues of each volume is necessary. However, since the Treasurer's books are closed in December before the bills for the December number of each year are payable, the Treasurer has to consider the total cost of the last issue of one volume plus the first three issues of the next in his annual report.

The Editor considers only the actual cost of printing and mailing each number, in order to compare it with the contents of that number. The Treasurer, however, adds in also figures pertaining to the cost and sale of reprints which are billed by his office. For these reasons, the figures of the editor, which apply to a given volume, and the figures of the Treasurer which apply to the business year of the Association, not only with respect to *Mosquito News* but with respect to other sources of income and expenditure, are not comparable except when considered issue by issue.

One large item pertaining to *Mosquito News,* included by the Treasurer, but not by the Editor, namely, the sale of reprints, during the last fiscal year amounted to $1,179.36 according to the Treasurer's report. This figure is not included by the Editor since it is a business matter outside the actual cost of publishing *Mosquito News,* and is not handled by the editorial office. For instance, in the Treasurer's report the cost of reprints is included in the $9,341.69 listed, but this figure does not appear in the Editor's report.

—D. L. Collins, *Editor*

ATTACHMENT #7

REPORT ON GOOD NEIGHBOR CLUB AS OF MARCH 30, 1960 *

(following AMCA Meeting)

Bank Balance, March 15, 1960		$401.31	
deposits March 30, 1960		95.00	
		$496.31	
Receipts to date			
Good Neighbors sponsored:			
Paid to AMCA	3	$ 15.00	
Paid to GNC	88	440.00	
Committed to GNC	27	135.00	
	118	$590.00	
Expenditures			
Postage		$35.00	
Good Neighbors of 1959		Total 120	
		— 11	
Paying own dues	7	109	Active for 1960
Deceased	1	12	New G.N.
Cancelled	3		
	11	121	Total
		118	paid for 1960
		3	lack sponsors

* Final figures calculated after the annual meeting.

—ERNESTINE THURMAN

ATTACHMENT #8

REPORT OF COMMITTEE ON SALE OF MISCELLANEOUS PUBLICATIONS

Financial Statement, December 31, 1959

CHECKING ACCOUNT

Balance as of January 1, 1959	$377.83
Total Deposits for the year 1959	+245.74
	$623.57
Total Expenditures for the year 1959 (Postage)	33.00
Balance as of December 31, 1959	$590.57

Number of Bulletins sold in 1959:
Nos. 1 and 2: 52
No. 3: 80

—C. T. WILLIAMSON,
Business Manager

ATTACHMENT #6

Report on Advertising in *Mosquito News*

January 1, 1959 through December 31, 1959

The figures below represent transactions during the calendar year 1959, for advertising in four numbers, Volume 18, number 4, and Volume 19, numbers 1, 2 and 3. (December 1958 and March, June and September 1959).

Number of active accounts	35
Number of pages of advertising	80¾
Receipts	$3,174.80

Expenses:

Postage, telephone, telegrams	$ 67.00
Printing, rate sheets, envelopes, letterhead	41.50
Honorarium for stenographer	10.00
	$118.50

Respectfully submitted,
—Francis P. Creadon
Advertising Mgr.

ATTACHMENT #9

Report of the Committee on Miscellaneous Publications

The progress of Bulletin No. 4 dragged badly this past year, due to a number of reasons. At our meeting in Salt Lake City, it was agreed by the Committee Members and the Board of Directors of the American Mosquito Control Association to give Bulletin No. 4 to Harold Gray for editing. We were unable to do this, due in part to the illness of Mr. Gray this past year, and due to the need for bringing up to date certain statistical information which had been acquired in 1952. Now it seems possible that within a short period of time—approximately three months—Bulletin No. 4 can be given to Mr. Gray for completion. It is anticipated that the statistical data will have been received by the Committee Members within the next three months.

I respectfully request that consideration be given to the selection of a new chairman for this committee. I find the coming year will pose numerous problems of sufficient size to reduce my time available for committee work. With this in mind, I would like to suggest the possibility of selecting one of the present Committee Members to fulfill the Chairman's responsibilities. In view of Harold Gray's current residence, I would suggest possibly the selection of Mr. Mulhern. I am sure they are in close contact, and Mr. Mulhern is fully aware of the progress of Bulletin No. 4.

—H. R. Greenfield, *Chairman*

ATTACHMENT #10

Report of Membership Committee

The 1959 season has been active and very encouraging to the American Mosquito Control Association membership committee. During the past year the Association has increased by approximately 200 new accounts. We have had 85 membership cancellations to offset some of the new memberships. The overall increase in membership was approximately 10 percent. The total of accounts is in the sixteen-hundreds for 1959.

The largest source of membership in-

crease came from the suggestion of our President, Archie Hess, that the membership committee contact a select group of pest control operators. Your membership chairman sent out letters to this group, as well as to other such groups, and invited them to become associated with the AMCA.

The large number of cancellations was caused mainly by a letter sent to the delinquent members and I asked for their cooperation and action on the delayed payment of dues. My letter was worded as diplomatically as possible and at the same time I did ask for their decision concerning the Association. In spite of this action there are still about 100 delinquent members being held over from the year 1959. I personally feel that this list should be published in the *Mosquito News* so that someone other than the membership committee can contact the individual if he so desires.

The alternate to this suggestion is that we drop these delinquent members as of June 1, 1960, or at least before the June issue of *Mosquito News* is mailed. It is to be remembered that we in the Association continue to send *Mosquito News* to the members who are delinquent in their dues, and the mailing alone is a very costly item. This has been a problem for a number of years and it may be embarrassing to some of the membership. However, the executive board does need a more direct course for action.

Some of us forget that each member of the AMCA is a representative of the membership committee. By that I mean, many of us meet people who are actively interested in mosquito control. We are obligated at least to invite all interested parties to be members of this outstanding organization. The $5.00 for membership is one of the best investments that one can be offered. *Mosquito News* is a source of guidance for every mosquito control worker and it certainly gives him the opportunity to make contacts with other people interested in this activity and who may be in a position to help him in case of need. The Association is worthy of merit and all the backing that the membership can give it.

Delinquent dues create difficulties for the executives of our organization, especially the secretary and the treasurer. Therefore, each member of the Association is obligated to support these officers rather than to cause them unnecessary work.

—P. BRUCE BROCKWAY, JR.
Chairman

ATTACHMENT #11

REPORT OF COMMITTEE ON PUBLIC RELATIONS

EXHIBIT: The AMCA Exhibit has had a fairly busy year. Last April it was on display at our annual American Mosquito Control Association meeting in Salt Lake City. From there it went to the Moses Lake Mosquito Abatement District in Washington. In early December it was shown at the Entomological Meeting at Detroit. It is here at this meeting in Boston.

It is scheduled to go to Virginia where it will be repaired, if needed, and shown. It will be shown at the Florida mosquito meetings at Tampa April 25–27. Through the special efforts of Committee member W. P. Warner, the exhibit will be shown at the Silver Anniversay Conference of the National Association of County Officials at Miami Beach, Florida August 14–17, 1960. An inquiry was received from Panama requesting a loan of the exhibit by the Health Bureau, Canal Zone Government; however, for some reason this did not work out. From all reports it has been favorably received wherever shown.

This exhibit could be shown much more extensively if cost of transportation were available. It has been suggested that perhaps some commercial company might be interested in underwriting such an expense. It is suggested that the President announce at this meeting that any mosquito control organization can obtain the exhibit for showing and that they will have to agree to pay shipping cost, arrange for storage until called for, and agree to ship to the next user.

Anti-Insecticide Publicity: Your Committee members have corresponded regarding the adverse effect that some publicity pertaining to the use of insecticides has had on mosquito control activities. It has been suggested that an article be prepared for a popular magazine, such as *Reader's Digest.* Another suggestion has been made that a special pamphlet be published under the name of the American Mosquito Control Association and that this be made available to the mosquito control organizations on an actual cost basis. It is recommended to the incoming officers that arrangements be made for financing such an undertaking and that a special committee be appointed to write the material for the pamphlet and a popular magazine article.

Series of Articles: It has been further suggested that a series of articles be prepared on the merits of mosquito control which could be used in Sunday paper magazine sections or for other newspaper releases.

Better Public Relations with Manufacturers: It was felt by your Committee that an effort should be made to improve the relationship between mosquito control organizations and supplying manufacturers. This would be considerably improved by affording them more time to demonstrate at annual meetings without competition from other parts of the program. Likewise, it seems desirable to have them take part in the formal program. This has been done to a limited extent and your Committee feels that the impetus should not be lost, but extended further.

More Practical Papers and Articles: Your Committee feels that more practical papers at the annual meeting and more operational articles in *Mosquito News* are needed. There is evidence that some districts have stopped sending representatives to the American Mosquito Control Association meeting for the above reason. Inasmuch as operational papers are not generally submitted, your Committee recommends that invitational articles on suitable subjects be solicited, even offering assistance in preparation if this is feasible.

Respectfully submitted:

—William S. Murray
Donald C. Grant
George A. Thompson
William P. Warner
Charles M. White
Franklin C. Wray
Archibald F. Cummings
Earle Potter
R. E. Dorer, *Chairman*

ATTACHMENT #12

Report of National Adviser

(Following is a press release which will serve as the report):

A National Mosquito Control-Fish and Wildlife Management Coordination Committee was organized today for the purpose of establishing objectives and considering general methods by which each field of public service might complement the other in the execution of their respective programs.

Elected to office were: Robert L. Vannote, Chairman, who is National Adviser of the American Mosquito Control Association and Secretary of the Morris

County (N. J.) Mosquito Extermination Commission, and Paul F. Springer, Secretary, who is Chief, Section of Wetland Wildlife Ecology and Management, Patuxent Wildlife Research Center, Bureau of Sport Fisheries and Wildlife, Laurel, Maryland. Other members of the Committee are: Dr. Ira N. Gabrielson, President of the Wildlife Management Institute; Dr. A. W. Lindquist, Chief, Insects Affecting Man and Animals Research Branch, U. S. Department of Agriculture, Beltsville, Maryland; Mr. K. D. Quarterman, Chief, Technical Development Laboratories, U. S. Public Health Service, Communicable Disease Center, Savannah, Georgia; and Mr. E. A. Seaman, Advisor on Fish and Wildlife Conservation, Office of the Provost Marshal, U. S. Air Force, and Secretary-Treasurer of the American Fisheries Society.

The objectives of the Committee were established as follows:

1. Coordinate mosquito control and fish and wildlife management policies on national, state and local levels.

2. Gather and disseminate relevant information and suggest standards on mosquito control techniques consistent with sound fish and wildlife management objectives.

3. Gather and disseminate relevant information and suggest standards on fish and wildlife management techniques consistent with sound mosquito control objectives.

4. Stimulate needed research and demonstration projects relating to mosquito control and fish and wildlife management practices.

5. Sponsor suitable meetings to further the purposes of this Committee.

6. Cooperate with agencies, organizations, and all others whose activities and interests may relate to those of this Committee.

The Committee will welcome suggestions on problems relating to the coordination of the two interests and has dedicated itself to the impartial examination of specific cases brought to its attention.

—R. L. VANNOTE, *National Adviser*

ATTACHMENT #13

REPORT OF RESEARCH AND DEVELOPMENT COMMITTEE FOR 1959

Last year the Committee, after canvassing mosquito control workers, suggested areas in which research was needed. The present report attempts a statement of the work that has been carried out in these areas, in the hope that it can thus be informative along lines of current importance. The committee members canvassed many organizations conducting developmental research, but these are not mentioned by name in the text, which follows as closely as possible the format of the 1958 report.

CONTROL OF *Culex*. No organizations are developing special control measures for *C. pipiens* and *C. quinquefasciatus*, since they are not disease vectors; yet they are the problem which is steadily intensifying around the expanding urban areas, and which Abatement Districts are expected to combat. Control measures are at present adapted from those developed for irrigation or floodwater species and for *C. tarsalis*.

It is generally considered (but not proved) that certain insecticides are largely inactivated in polluted waters because of adsorption; however others consider that DDT is taken by the larvae as an oral dose. The fact remains that DDT is an unsatisfactory culicide in polluted waters, in that it requires a high dosage to be effective. BHC and dieldrin are effective, sometimes for the season; there is a danger of developing resistance to these compounds, which so far has been limited to *C. quinquefasciatus*. Organophosphorus insecticides are effective in polluted waters,

DDVP and Phosdrin for a short time, EPN and malathion for a longer, and Diazinon, Guthion, Ronnel and Thimet being quite persistent. Malathion granules may be effective where sprays are not. DDVP is ovicidal, and Thiodan kills pupae. Malariols, diesel oils and unrefined fuel oils are effective but have not lately been a subject of developmental research.

There is no information on developments in the design of storm sewers to prevent *Culex* breeding. Biting habits of such *Culex* have not been recently investigated, although the autogenous *molestus* is known to occur. Recently, autogenous populations of *C. tarsalis* have been found and the biting habits of this species, particularly on birds, have been extensively reported. Hibernation sites of *C. tarsalis* have been discovered in loose rock talus in northwest U.S.A.

The reduction of weeds, rather than encouraging *Culex* breeding, is an essential element in *Culex* control, at least for *tarsalis*. The use of top-minnows (*Gambusia*) has been found to be economic in small breeding pools, provided vegetation covers less than half of their area.

Control of Floodwater Mosquitoes. Concern for economy in area treated has led to investigation of flight patterns of the adult broods. It appears that *A. nigromaculis* in California does not show the movement characteristic of *A. taeniorhynchus* and *A. sollicitans* in Florida. *A. vexans* and other species breeding on the Alberta prairies have been found to descend into the river valleys and move along them, so that barrier sprays across the valley can protect a city therein.

Development of pre-hatching treatments in southeastern U.S.A. has shown that DDT at 1 lb./acre offers protection for the season, while the effect of dieldrin at 1 lb./acre can extend for 4 seasons.

In an attempt to find agents that will destroy eggs without leaving toxic residues, and exploiting the fact that reduced oxygen content is a hatching stimulus, experiments are being made in California with respiratory poisons as ovicides.

Irrigation Mosquito Problems. Reasons are being sought for the fact that no two fields are alike in breeding mosquitoes. One basic principle, it is now considered, is that the highly productive fields are those in which water stands for a period long enough to allow completion of preadult development. The factors determining production have been characterized in Utah. Work on the western prairies of U.S.A. has shown that *A. nigromaculis* is characteristic of irrigated fields, *A. melanimon* of ditches and sloughs, while *A. dorsalis* can develop in alkaline seepage areas. The best land practice known at present to prevent breeding is to level the field and install efficient drainage systems.

Development of insecticides to be added to the irrigation water as it is supplied is a matter mainly of cost; the present insecticides are too expensive to allow treatment of the large amounts of water involved to be economic. Residual insecticides for pre-flood treatment of fields at present include heptachlor and dieldrin, which have been tested in Colorado and Oregon. Control for the season, in the absence of resistance, may be obtained by heptachlor at 0.5 lb./acre and dieldrin at 0.25 lb./acre, from granules or emulsions. An application of dieldrin at 1 lb./acre gives control for 2 seasons, becoming unsatisfactory for the third season. However, residue regulations do not allow the use of these chlorinated hydrocarbons on pasture or haylands, leaving malathion as the insecticide of choice.

At their present stage of development, granular formulations are about as effective as sprays. In California, parathion granules have been found successful and malathion granules promising; however in Oregon malathion granules failed where heptachlor succeeded. Information has been obtained on the rate of release of parathion from granules and of its adsorption onto the soil. Clay formulations release insecticide very slowly, and thus the development of sand cores may prevent the loss occasioned by retention on the granules. Paris green granules on vermiculite have proved successful in Florida, particularly against the increasing *Psoro-*

phora problem. For application of these granules, the 'Swathmaster' has proved the best applicator to appear so far.

RESISTANT MOSQUITOES. Recent developments have done much to answer the questions in the 1958 report, as follows:

1. The mode of action of all present organic insecticides is by poisoning nervous activity. The chlorinated hydrocarbons affect the action potentials of nerve, the mechanism being unknown for BHC and dieldrin, although it has recently become clearer in the case of DDT. The organophosphorus insecticides are oxidized in the body to enzymes that inhibit the nerve enzyme cholinesterase. Carbamate compounds such as Sevin are also anticholinesterases.

2. Mechanisms of resistance are now divided into 3 groups: DDT-resistance, dieldrin-resistance and OP-resistance. DDT-resistance in mosquitoes sometimes is associated with increased DDE production, as in houseflies. Nothing is known of the mechanism of resistance to dieldrin or BHC. OP-resistance may be due to increased detoxification of the oxidized toxicant, as in houseflies. Increased lipoid has been found in some resistant strains but not in others.

3. DMC, which interferes with DDT-detoxification, was not sufficiently synergistic with DDT for resistant *A. aegypti,* and no synergized mixtures are now used in mosquito control. Of the negatively correlated compounds which could theoretically reverse resistance, CBA is not negatively correlated for *Aedes,* and PTU is not sufficiently toxic.

4. The genetics of resistance is being thoroughly studied in mosquitoes. DDT-resistance in 3 species, and dieldrin-resistance in 1 species, has been found referable to a single gene allele. Genetical technique is being applied to estimate gain and loss of resistance, and to differentiate between true resistance and vigor tolerance.

5. As a new type of control technique, sterile males of *An. quadrimaculatus* have been released; it was found that very large numbers are required for an effect. This method is now being tested for *Ae. aegypti.* Using chemicals in a new way, it has been found that certain halogenated carbinols reduce the egg production of *A. aegypti* as well as of house flies. The most promising compounds against resistant *C. tarsalis* larvae found this year are Bayer 29493 and Geigy 30494. The reintroduction of paris green as a larvicide is promising because it has no record of inducing resistance in the past.

7. The role of pathogenic organisms in insect control has recently been reviewed in a special conference at Washington. The unicellular fungus *Coelomomyces* is being tested for *Aedes* control on a western Pacific island. The use of the blue-green alga *Anabaena,* which produces a toxin for mosquitoes but not for higher animals, was found promising in California, but subsequent tests in Utah showed that mosquito larvae could complete their development before the toxin accumulated, there being no carryover from one year to the next.

EFFECT OF INSECTICIDES ON FISH AND WILDLIFE. A recent symposium on coordination of mosquito control and wildlife management, and a conference of entomologists with the Conservation Foundation, have done much to bridge an estrangement between the two groups. Fish and wildlife interests are more frequently participating in the planning of mosquito abatement operations. The 3 points raised under this heading in the 1958 report may be covered as follows:

1. DDT at 0.1 lb./acre has been found not to affect the numbers of animals and birds, and the reduction in crustacea such as crabs and shrimps is only temporary. DDT at 0.2 lb./acre sometimes involves mortality of fish, roughly equivalent side-effects being given by repeated doses of 0.1 lb./acre. The Fish and Wildlife Service recommended that the 0.2 lb./acre dose be restricted to single treatments. It is realized that secondary accumulations due to wind action on deposits may cause spot mortalities of fish or other vertebrates.

2. Apart from the observation that 100 p.p.m. of DDT in the diet reduced the egg fertility and increased the nestling

mortality of quail, nothing is yet known about the effect of DDT and other insecticides on the reproductive rate of birds in the area treated.

3. Development of new insecticides is mainly in the organophosphorus group. Although malathion is considered to be slightly more toxic to fish than DDT, there is great variation in response between different species. The USPHS laboratory at Cincinnati is assessing the toxicity of new compounds to fish, and is concerned with the accumulation of insecticides from run-off into rivers. Paris green granules may well be one of the insecticides with the least side-effects on wildlife.

Respectfully submitted,
—A. W. A. BROWN, *Chairman*
W. R. BUNN
W. R. HORSFALL
K. L. KNIGHT
M. W. PROVOST
K. D. QUARTERMAN
G. E. SMITH

ATTACHMENT #14

REPORT OF COMMITTEE ON LEGISLATION

The Legislative Committee of the AMCA, composed of representatives from each of the geographic regions, wishes to report that no requests have been received for Federal legislation regarding mosquito abatement with the exception of a continuing request that the districts be allowed to purchase Government surplus property without coming under the jurisdiction of Civil Defense.

Respectfully submitted,
—E. CHESTER ROBINSON, *Chairman*
F. P. CREADON
C. T. WILLIAMSON
DR. PAUL R. MEYER
LAVERNE MILLER
J. A. MULRENNAN
ROWLAND E. DORER

ATTACHMENT #15

REPORT OF THE RESOLUTIONS COMMITTEE

RESOLUTION NO. 1

WHEREAS, the general assemblage at this sixteenth Annual Meeting of the American Mosquito Control Association held in conjunction with the Northeastern Mosquito Control Association in the City of Boston, has found these sessions, facilities and arrangements to be of enjoyable and of excellent nature,

NOW THEREFORE BE IT RESOLVED that we herewith offer expression of our appreciation and gratitude to Dr. William E. Bickley and members of this Program Committee for the schedule of interesting and informative presentations,

The Northeastern Mosquito Control Association as host for these meetings,

Robert L. Armstrong, General Chairman of the Arrangements Committee and his many fellow workers for the very considerable effort, organization and efficiency exhibited in the preparation and conduction of these meetings,

The Somerset Hotel for provision of these enjoyable facilities and attendant operations,

The many commercial exhibitors and members in attendance at these meetings for their meritorious displays, participation and contributions, with special appreciation of additional hospitality and constructive aid rendered to these Associations,

And the many speakers and participants who through their presentatitions and

efforts have so capably provided such merit and knowledge and understanding towards the advancement of mosquito control throughout the world.

RESOLUTION NO. 2

WHEREAS the dosages of insecticide used in mosquito control are very much less than those used in forest or for crop protection, and have been shown by recent wildlife studies to be thus far entirely without deleterious or harmful effect on the abundance of birds and mammals, and almost invariably without effect on fish;

WHEREAS there has recently been an extensive exchange of information between mosquito control and fish-and-wildlife experts at two national conferences, there is an increasing trend for fish-and-wildlife experts to be consultants in the planning of mosquito control activities wherever concerned, and there has been formed a National Committee for the Coordination of Mosquito Control with Fish and Wildlife Management, as a continuing safeguard;

RESOLVED that the American Mosquito Control Association make it known that it repudiates any suggestion that mosquito control, as carried on by approved methods, jeopardizes the interest of the public by sacrificing, or destroying fish and wildlife of value.

Respectfully submitted:
—ROBERT L. ARMSTRONG
A. W. LINDQUIST
C. DONALD GRANT,
Chairman

ATTACHMENT #16

AMERICAN MOSQUITO CONTROL ASSOCIATION, INC.
COMMITTEE CHAIRMAN AND SUGGESTED COMMITTEE APPOINTMENTS
FOR 1960 FOR ACTION MARCH 30, 1960

Editorial Staff, Mosquito News: Editor: Donald L. Collins; Miss Helen Sollers, Mrs. Helen Louise Durkee, William C. McDuffie, Austin Morrill, Jr.

Business Mgr. Miscellaneous Publications: C. T. Williamson

Editorial Board (Standing Committee) on Publication of Mosquito News: Chairman: Kenneth L. Knight; Richard Darsie, Jr., Richard B. Eads, Harry D. Pratt, Richard Peters, Andrew Rogers

Standing Committee on Legislation: Chairman: E. Chester Robinson; *Vice-Chairman:* Rowland E. Dorer; F. P. Creadon, C. T. Williamson, Paul Meyer, J. A. Mulrennan, Glen Collett

Standing Committee on Research and Development: Chairman: A. W. A. Brown; R. W. Bunn, Maurice Provost, William R. Horsfall, Lyle E. Hagmann, C. M. Gjullin, Gordon E. Smith, John W. H. Rehn, Kenneth D. Quarterman

Standing Committee on Finance: Chairman: Charles F. Scheel, and subcommittee from President's Advisory Committee including certain present and past officers as Policy and Finance Council

Standing Committee on Bylaws: Chairman: J. A. Mulrennan; Richard F. Peters, Bailey B. Pepper, Robert Armstrong, C. M. Gjullin, K. D. Quarterman, John Hughes

Standing Committee on Public Relations: Chairman: Rowland E. Dorer; *Vice-Chairman:* William P. Warner, C. Donald Grant, Earle D. Potter, William S. Murray, Franklin C. Wray, Frank J. von Zuben

Standing Committee on Membership: Chairman: P. Bruce Brockway; *Co-Chairman:* A. W. Buzicky, and all Regional Directors

Standing Committee on Miscellaneous Publications: Chairman: C. Donald Grant; Hugo Jamnback, T. D. Mulhern, Harry D. Pratt, Carroll N. Smith, Franklin C. Wray

Committee on Sale of Advertising Space: Chairman-Manager: Francis P. Creadon and members of certain committees

Nominating Committees: Chairman: A. D. Hess; Robert Armstrong, Robert Ostergaard, Gordon Smith, William Cox, Kenneth Quarterman, Carroll N. Smith, William Rapp, Franklin Wray, Don M. Rees, Robert Harwood, Chester Robinson, Gardner McFarland, Thomas Aitken, John McClintock, Patrick Nakagawa, John M. Hirst

Committee on International Exchange and Good Neighbor Club: Chairman: Ernestine B. Thurman; A. W. A. Brown, Don Pletsch, Donald Johnson, Eugene Gerberg—and suggested Associates

National Advisor: Robert L. Vannote
President's Advisory Committee, including Subcommittee on Policy and Finance: Chairman: Robert L. Vannote; Arthur Lindquist, Fred H. Stutz, Richard Peters, Rowland E. Dorer, Fred C. Bishopp, C. R. Twinn, Don M. Rees, Lester W. Smith, Harold F. Gray, M. D. Peters, Harry H. Stage, C. T. Williamson

ATTACHMENT #17

Report of Special Committee to Consider Consolidation of Business Activities

The bylaws state that the President shall have the usual responsibilities and powers of supervision and management, such as pertain to his office and such other powers as specified in the bylaws or properly assigned by the Board.

The Executive-Secretary is empowered, among other duties, to coordinate the objectives, policies, responsibilities and services of the Association.

The Board of Directors is empowered to "prescribe policies governing the activities and functions of the Association."

Therefore, in an effort to consolidate several of the administrative functions of the Association which will result in more effective and efficient service to our membership and in concurrence with the advice and approval of the Executive-Secretary, your President recommends the following transfers of function for Board approval:

1. That as soon as practical the library, now located in Barnegat, New Jersey, be transported to the Executive-Secretary's office and that the duties now performed by Walter Henderson be assumed by the Executive-Secretary immediately on completion of the transfer of the property. The Editor of *Mosquito News* is requested to make a suitable announcement giving the date the Executive-Secretary will assume these library duties.

This recommendation is made to improve and centralize the operation of this function and in no way discredits its current administration.

2. That as soon as practical the surplus supplies of Association bulletins and other publications be transported to the Executive-Secretary's office for sale and distribution. This recommendation is made with the approval of the Business Manager and is designed to improve and centralize the administration.

3. That the clerical services of the Good Neighbor Club be administered by the Executive-Secretary under the direction of the Chairman of the Good Neighbor Committee.

This recommendation has been indorsed by the Chairman of the Good Neighbor Committee and is designed to centralize the clerical and administrative function of this activity in the Executive-Secretary's office.

VIRGINIA MOSQUITO CONTROL ASSN.

5721 Sellger Drive, Norfolk 2, Virginia

George C. Lyon, Ocean Park, President

Jack E. Dent, Norfolk, First Vice President

Philip P. Davis, So. Norfolk, Second Vice President

C. E. Johnson, Hampton, Third Vice President

R. E. Dorer, Norfolk, Secretary-Treasurer

D. K. VISWANATHAN—IN MEMORIAM

Dr. Dharmavadani Krishnier Viswanathan, Senior Regional Malaria Adviser to the Regional Office for South East Asia, died on 27 March 1960.

Dr. D. K. Viswanathan was born on 1 March 1901 in Tirunelveli (Madras State). He obtained his medical degree at the Medical College in Madras in 1923 and his Diploma in Public Health at the same school five years later. In 1937 he obtained a degree of Master of Public Health at the Johns Hopkins School of Hygiene, Baltimore, U.S.A. From 1943 until 1952 he held the post of Assistant Director of Public Health with the Government of Bombay State. In 1952 he became the Director of Public Health Service of the Government of Bombay, in charge of Public Health Administration, and held this post until 1956 when he joined the World Health Organization and became Senior Regional Malaria Adviser to the Regional Office for South East Asia.

Dr. Viswanathan was a Member of the Committees of the Indian Council of Medical Research, the Council of Scientific Industrial Research, the WHO Expert Advisory Panel on Malaria and a Fellow of the Indian Academy of Sciences.

The loss of "D.K.," as he was affectionately called, came as a brutal shock to all his friends. It is difficult to believe that this unforgettable man, whose boundless energy and brilliant intellect were so widely known, has gone forever. Malariology has lost in Viswanathan one of its outstanding specialists, a man who has blazed a trial towards malaria eradication in India and in the world. Viswanathan's interest in malariology dates from 1927 when he was Asistant Medical Officer in Madras. In 1935, in the capacity of Malaria Officer of the Madras Presidency, his was the task of controlling malaria over an area of 142,000 square miles with a population of 47,000,000. In this he was assisted by one entomologist and by a budget of about $26,000!!

The DDT era in India started on 1 July 1945 in Dharwar and Kanara districts of Bombay Presidency, at Viswanathan's insistence and thanks to a small supply of the insecticide given by the Army. The success of this first trial was such that by 1949 about 6,000,000 people were under protection in Bombay State. By 1952 over 30,000,000 people were successfully protected from malaria in India and in 1955 the Indian National Malaria Control Programme came into being, only to be succeeded two years later by the organization of the present National Malaria Eradication Service which, assisted by WHO and ICA, protects a population of 390,000,000.

Although the part played by Viswanathan in the early stages of this program was limited to Bombay State alone, there is little doubt that "D.K." 's experience, drive and extraordinary talent of persuasion contributed greatly to the success of this largest malaria eradication campaign in the world.

"D.K."s numerous published papers and countless letters and notes are marked by his deep understanding of the epidemiological bases of malaria, by the originality of his approach and his facility of expressing his thoughts. His book "Malaria and its Control in Bombay State," published in 1950, contains many ideas which were in advance of that time. His 1958 monograph "Conquest of malaria in India" makes delightful reading because of its liveliness and interesting historical sketches.

For the past four years Viswanathan held the post of WHO Senior Regional Malaria Adviser responsible for malaria eradication programs over an enormous area of the South-East Asia Region where 506,000,000 people were exposed to the disease. He took up and carried on this difficult job with a phenomenal energy and without sparing himself. His work as an inspired leader, careful guide and

critical judge has been outstanding and his departure has left a gap that will be difficult to fill.

Viswanathan had a double personality in which the East and West were extraordinarily blended. He was a Western man with his belief in material progress and his respect for Cartesian logic; but he was also (and even more) a devoted Brahmin Hindu, a mystic, regarding all earthly phenomena as evanescent and aspiring to the union with the Infinite.

Viswanathan was a brilliant conversationalist able to quote John Donne and the Bhagavad Gita with equal facility and fervor. He was an excellent speaker, amusedly aware of the fact that his eloquence was at times a sore trial to clock conscious chairmen. He had a noble courage of his own beliefs, and convictions and could be a formidable adversary in polemical jousts. A kind, loyal and generous friend, he is mourned by all those who knew him. Our deep sympathy goes to his wife, Lakshmi, his son and two daughters.

Nothing can show D. K. Viswanathan's personality better than an extract from his last letter written to some friends in the World Health Organization two weeks before his death.

"The medical pundits have at last declared that my condition is one of myeloma. . . . They are exploring the possibility of my getting treatment by irradiation in India. . . . but if it is not available there is no option . . .

. . . "I have some notes and bits of news on the strategy of eradication of malaria and on our present knowledge of the epidemiology of disappearing malaria. It will not be unfitting if I present the Organization with this humble token of my last testament. I can dictate it during those moments that are available between my bouts of pain, prayer and pethidine. I am able to do this for about one hour every day; I hope to have the notes completed by the end of May but these 60 minutes a day have to be made up of at least 12 snatches of 5 minutes each, when I am physically able to concentrate my attention.

"Though not over-modest in the past, during the last few years my service with an international organization has taught me a few basic virtues like humility, patience and human understanding.

"All things must come to an end in this world. I am not worried about it. I have lived well, served well, have a good family and above all, excellent comradeship in my official work. So I am quite prepared to meet my Maker."—L. J. BRUCE-CHWATT.

LOUIS A. STEARNS

Louis A. Stearns, 67, professor emeritus of the University of Delaware and a widely known entomologist, died on March 4 in a veterans hospital in suburban Elsmere. Mr. Stearns suffered a stroke a week ago.

Mr. Stearns' outstanding work in Delaware was as an expert in mosquito control. He developed several methods of ridding plagued areas of mosquitoes. They were so successful that many agencies outside the state used them.

Mr. Stearns retired in 1957 after 28 years as head of the university's department of entomology.—From the *Washington Post,* March 5, 1960.

NEWS AND NOTES

AUSTIN W. MORRILL, JR.

OUR EARLY DEADLINE OF LAST ISSUE MEANS THAT SOME OF THE NEWS YOU'RE ABOUT TO GET ISN'T REALLY THE LATEST FLASH BUT WE THINK YOU'LL STILL BE INTERESTED TO KNOW THAT ARCHIE HESS HAS BEEN TO BRAZIL to attend a Malaria Eradication Conference (peace, Harold Gray . . . Malaria *Control* Conference) in the little city of Petropolis, near Rio de Janiero. Besides working to map out international programs, the conference also worked on a standardization and simplification of terms, a welcome thing certainly, but a hard task. From Rio, Archie came back by way of San Juan, Puerto Rico, and Trinidad. We bet Archie got a swell lot of pictures en route, along with all else he did, including, no doubt, some of Brasilia before opening day.

ON 25, 6 and 7 January, just too late for the above mentioned deadline, the California Mosquito Control Association held its annual meeting in Marysville, California, with T. M. Sperbeck as host and enlivened by some of the most provocative and stimulating discussions we've listened to in a long time. From afar, came AMCA'ers GLENN COLLETT, H. C. CHAPMAN, J. E. GRAHAM, C. M. GJULLIN, GAINES W. EDDY, LOUIS OGDEN, and from far off Minneapolis, AL BUZICKY headed a *delegation* which included the Chairman of his Board! RALPH BARR and his associates presented reports on some excitingly new attacks on old, old problems, including such things as a workable trap for larvae, to supplement dipping and plain observations; a method of spraying things onto aëdine egg-laying grounds to make the eggs hatch prematurely or delay them fatally; the discovery of new mosquito diseases, particularly a horrible-looking *Microsporidium* and what may be the world's first discovery of a bacterial disease of mosquitoes; and finally a paper by BETTINA ROSAY on morphological changes in adult mosquito females which will give us clews to how long they've been emerged and by inference how far they could have come from.

There was also a wealth of papers on practical problems of equipment and abatement district management among which one by DAVE REED was particularly noticable as aiding those of us who try to sell proper irrigation water management to people that aren't particularly interested in whether or not they cause mosquitoes. Dave showed the dollars and cents improvement in the farmer's crop and cattle yields which ought to make that old pocket-book nerve vibrate like a violin string. All these fascinating papers will be available in the Proceedings. DR. STAN FREEBORN, recuperating from a rather serious operation, was unable to attend but was voted honorary membership, hitherto uniquely held by HAROLD GRAY, the vote receiving a resounding ovation. (Stan says he's fine now, but holding the line for a while; no extras.) Dr. GARDNER MCFARLAND was elected President, LES BRUMBAUGH, President-elect, JOHN BRAWLEY, Vice-President, and Dr. DON MURRAY, Secretary. Oh, yes, . . . VMCA's super-excellent film on Mosquito Control in Virginia, applicable anywhere, was shown to a large and enthusiastic audience and it received a real ovation, too. This film has a real professional finish and would make a wonderful color presentation on our local educational TV or school circuit.

VIRGINIA MOSQUITO CONTROL ASSOCIATION'S meeting was held on 23 February, in Craddock, Virginia. VMCA has no dues and no registration fee and all interested mosquito control types are cordially invited. (Remember this for next year!) *We* remember how good their meetings always are. On the program this year were BOB VANNOTE, Dr. BILL BICKLEY, Dr. DAN JOBBINS, Dr. RICHARD HAYES and Dr. CHUCK GERHARDT. Among the other interesting practical discussions was one on Television as a Training Medium, which is becoming more and more pertinent to mosquito control people. (See previous paragraph.) R. G. CARTER and HARRY L. GILBERT were represented by a paper and LESTER SMITH was the Voice of AMCA. Wish *we* could have been there! Volume VII, No. 2 of VMCA's *Skeeter,* which reports on this is the next best thing!

NOT TO BE OUTDONE, THE YOUNG AND VIGOROUS UTAH MOSQUITO CONTROL ASSOCIATION host of a memorable AMCA convention last year, held its annual meeting on 18 and 19 March, 1960, in Brigham City. LEWIS NIELSEN sent us a note that the meetings were interesting and we know from long experience with all sorts of meetings that the proceedings will reach us just after this issue goes to press, so you'll have to send for the proceedings to learn more. (Advt.) However, we have a paper of Dr. Nielsen's, published in the Utah Academy Proceedings, Vol. 36, in 1959, and just received, on the distribution of *Aëdes* mosquitoes in the snow regions of the Rockies, which is a mighty interesting piece of work. He describes careful observations which modify our ideas somewhat on such species as *communis* and *hexodontus,* of interest to many who don't have Rocky Mountains.

US DISENFRANCHISED NON-ATTENDING MEMBERS WERE CHEERED TO LEARN FROM SCOUTS RUNNING BACK FROM THE BOSTON MEETINGS THAT ERNESTINE THURMAN is going to take over the duties of Recording Secretary. We don't know how she does all that she does do but she does it (she is also recording secretary for the Washington Entomological Society, too, for instance) and, by golly, we know she'll turn in her usual accurate,

workmanlike, discerning job for AMCA's records. Her Good Neighbor Club activities, having been vigorously fruitful, should alone have earned her a nice restful assignment with lots of honors and no work, but the needs of the Association *Come First!* Mrs., Dr., Commander Thurman. Aren't we lucky we have you?

RUSS FONTAINE WAS THE HONOR GUEST AT THE BANQUET OF THE CALIFORNIA MOSQUITO CONTROL ASSOCIATION ENTOMOLOGY SEMINAR at Berkeley on the 15th and 16th of April. He gave us a fascinating profile of the vector and pest situation in equatorial Africa, especially Ethiopia and its neighbors. We wish we could do justice to his talk but scribbling statistics as fast as we could we were able only to catch a few. Russ said that at elevations below 7000 feet *A. gambiae* is a very efficient vector, so efficient, in fact, that most of the people have moved upland. *Gambiae,* like its cousins in other tropical places is most effective at the beginning and end of the rainy season, when the rain is not sufficient to "wash them out." Forty to fifty percent of the population are infected; in 1958 there were some 3,000,000 cases recorded around November. Fifty to sixty percent of these cases were *falciparum* and about twenty percent more were *vivax* and *malariae* (each). There are few pest mosquitoes other than vectors, Russ went on to say, though there are about ten species. The diseases include malaria, typhus, yellow fever, relapsing fever, trypanosomiasis, leishmaniasis and filariasis, so you can see they have a real problem and a lot of hard work ahead of them.

ILLINOIS MOSQUITO CONTROL ASSOCIATION MEETINGS WERE HELD 7 and 8 March in Decatur, Illinois, and we're sorry that the announcement reached us too late for the March issue. A mighty interesting session was set up in symposium form for the starter, the discussion concerning safety measures in mosquito control and covering dangers, the insurance company viewpoint and preventative measures. Two other panel discussions covered problems of district organization and practical operations, the latter including pre-hatch control, drainage, chemical control and the forms in which chemicals may be applied. A discussion of the coördination of Government agency programs and those of mosquito abatement districts concluded the meetings.

TOMMY MULHERN HAS SENT US A COPY OF A VERY INTERESTING REPORT HE HAS PREPARED on position classification in California mosquito abatement agencies. This report contains detailed position descriptions and a limited number of copies are available for furnishing to agencies outside the State of California. The P.D.'s are concise and, what's more important, couched in the special language of personnel directors. They should be very useful to anyone plagued with writing position descriptions that will do justice to the job and convey information in the form in which personnel people need it.

NEW JERSEY MOSQUITO EXTERMINATION ASSOCIATION HELD ITS ANNUAL MEETINGS ON 15, 16 and 17 March, in Atlantic City. Their Proceedings have been so high and so sacred for so long that we won't try to scoop them here . . . particularly since we weren't lucky enough to be able to go, as we once always used to, and our report wouldn't be very accurate. However, ROLLIE DORER reports that he and one of his District assistant Superintendants attended as a return call on Manley Jobbins and Bob Vannote. Rollie presented a paper on the "Use of Surplus Airplane Fuel Pumps for Mosquito Control."

JOHN G. SHANAFELT, JR., ORANGE COUNTY (CALIF.) MOSQUITO ABATEMENT DISTRICT entomologist, who is also on the program committee for next year's AMCA meetings, included in the 1960 CMCA *Yearbook* a double page picture spread of Disneyland as a reminder of those meetings. The pictures are all of water and one is of water in lush tropical jungle growth! Doesn't that whet your instincts, mosquito men? Incidentally, the beautiful print job was done by John himself, in his home hobby shop. And *we* can't even type very well! Entomologists are sure various.

THE ANNUAL REPORTS OF THE KINGS COUNTY AND YOLO COUNTY (CALIF.) MOSQUITO ABATEMENT DISTRICTS, THE DESPLAINES VALLEY (ILLINOIS) AND SALT LAKE CITY MOSQUITO ABATEMENT DISTRICTS AND THE METROPOLITAN DADE CO. (FLA.) MOSQUITO CONTROL DIVISION are all so impressively got up that comparisons would be invidious and, besides that, impossible. And they are all so full of useful observations and tables and photographs we cannot do them justice here. Did you know that in addition to their other duties, as the military phrase goes, the Salt Lake City control people stocked all 602 ornamental ponds in their city with *Gambusia?* Did you know that Desplaines, not to be outdone, has stocked 16 wildlife oases with *Gambusia,* as well as 15 more backyard pools, and found that while only 3 containing fish were breeding mosquitoes, 29 without fish were full of mosquito larvae? Did you know that Miami's anti-mosquito-fish fish, previously noted here, is spreading a little but just can't stand cold weather, and they've started feeding on mosquito larvae themselves? JOHN BRAWLEY'S Kings County report has a picture of his airplane flying along so close to the ground you'd assume it was landing if you hadn't seen the pilot at work, but golly, that's the way he sprays . . . right on the deck and we mean *right* on the deck. And GEORGE UMBERGER'S Yolo County report includes a study on flight patterns which provide another brick in the structure of knowledge of this important but still incomplete part of mosquito control.

ROY W. CHAMBERLAIN recently addressed a symposium on epidemiology and laboratory aspects of eastern viral encephalomyelitis, according to the February issue of *Lab World.* Dr. Chamberlain, Chief of the Communicable Disease Center's virus vector research unit in Montgomery, Alabama, told

the group meeting at the University of Pennsylvania, that many factors had to come into the picture of mosquito population, bird population and victim; that is, horse and man.

DICK EADS writes that he has exchanged his old job as principal entomologist for the Texas State Department of Health for one as Senior Scientist (Commander) in the U. S. Public Health Service. He had been with the Texas Department of Health since 1939, with time out for three years graduate work and three years in the Navy on malaria control during World War II. Dr. Eads' present assignment is Station Entomologist, at the U. S. Quarantine Station, Brownsville, Texas. He gave up Austin OK, but he couldn't give up Texas. We know how that is, though we had to give up Texas a long time ago, part way, anyhow. We wish him luck in his new assignment!

G. ALLEN MAIL wrote us a month or so ago that as of 31 December 1959, he had retired from the U.S.P.H.S. in Phoenix, Arizona, and is now living in Tucson, where his address is 3020 E. 3rd. St. He says that after 2½ years of seeing his family only on weekends it feels grand to be home all the time but he doesn't plan to stagnate and will welcome visits from all AMCA'ers who come to Sun Land.

ALTHOUGH HARRY HOOGSTRAAL IS NOT AN AMCA'er (AND WHY NOT, HARRY?) he is so well known to so many of us that we thought you'd like to know that he has been presented with the Secretary of the Navy Distinguished Civilian Award for his contributions to naval medical research in the field of epidemiology. Dr. Hoogstraal, at the Naval Medical Research Unit No. 3, Cairo, Egypt, is best known for his contributions on ticks and ectoparasites but he has worked with many of us around the world on mosquito problems, too. During the war, with the Army's 19th Medical General Laboratory up through the Islands, he made friends with natives and foreigners alike throughout that vast area and he has more recently been the recipient of accolades from the Egyptian Government and people, not lately given to accolades toward the United States.

SPEAKING OF COUNTRIES THAT DON'T LIKE US, WE HAVE BEEN THE RECIPIENTS OF A STIRRING APPEAL FROM THE MINISTERIO DE SALUBRIDAD Y ASISTENCIA HOSPITALARIA DE CUBA, dated "Year of the Liberation" and appealing to us to use our influence to get the bust of Dr. Carlos J. Finlay placed in the Hall of Fame of New York University as the conqueror of yellow fever. The Historian who writes the letter points out that Drs. Walter Reed and William Gorgas are already represented there and sends a rather truculent publication which claims that we Americans have deliberately and unanimously refused to give Dr. Finlay his due. This is, of course, nonsense and we, for one, have never seen an account of the fight against yellow fever which did not give Dr. Finlay credit for his years of crying in the wilderness. The fact is, of course, that he is ineligible for the Hall of Fame simply because he was not an American of the United States of America and did not become so by serving as a civilian contract surgeon with the United States Army, however meritorious his work. We thought we'd explain all this for our Cuban friends who may not know the whole story.

WE HAVE A FINE PUBLICATION OUT OF RUSSIA ENTITLED ENTOMOLOGICAL REVUE, WHICH HAS BEEN TRANSLATED BY THE A.I.B.S. This revue is a periodical and is regularly reprinted in English by the Institute and a very worthwhile method of keeping up with things entomological on the other side of the world. This particular issue recently sent us has some very fine *Aëdes* keys for females of forest species, including such locally interesting ones as *nigripes, excrucians, impiger* and *sticticus,* to say nothing of *communis* and *hexodontus.* There is also an interesting discussion of *Anopheles maculipennis* in the Northern Districts of Belorussia (Byellorussia?), its emergence, fly-outs (from swampy breeding zones), hibernation and malaria vectoring. The Revue is intended for subscription by libraries and is priced at $25.00 per annum, a bargain, but the A.I.B.S. might entertain orders for single copies. Their address is 2000 P St. N.W., Washington 6, D.C.

ALBERT E. WEYER IS CURRENTLY LABORING IN LIBERIA and has written a fascinating letter to the American Society of Professional Biologists, which was duly published in the *News.* It's too long to summarize but in addition to malaria control, cockroach control, ant, bee and milliped control, and such, he has learned to take microscopes apart, clean out the fungi and put them together in focus. This is no common ability, so he finds himself now flooded with offers to lend him material to practice upon, the material to be returned when fixed. Al's boss, Firestone, says, "There's not another man in the whole organization with a job comparable to yours," and Al isn't sure just how to take that. His malaria program covers 90,000 acres on one plantation and 6,000 on another and they extend themselves out two miles all 'round as a protection. They spray over 22,000 houses a year and despite dieldrin resistance, Al thinks they've been pretty successful considering that when he started they often found over 25 *A. gambiae* per square *foot* of wallspace.

HOW MANY OF YOU READ NEWSWEEK REGULARLY? WELL, YOU OUGHT TO. OUR ESTEEMED COMTEMPORARY RECENTLY "HONORED" ART LINDQUIST with an article entitled "Sex in the Swampland" and it started out with about as apocryphal a quotation as one can imagine. But they did manage to stay fairly close to the text on what Dr. Lindquist had to say, which was all about the recent studies on sterilization of males with irradiation.

STAN CARPENTER IS NOW "COLONEL (USA-Ret.)" AND HAS JOINED THE CALIFORNIA BUREAU

OF VECTOR CONTROL IN THE KIND OF RETIREMENT PLAN EVERYONE DREAMS ABOUT. During the summers he will be in the High Sierras (where lesser folk have to pay for their vacations) happily collecting mosquitoes in the booming recreational areas and adding to and evaluating our knowledge of the pest species of these places. In the *winter,* he will remain equally happily ensconsed in his estate in Sonoma . . . the valley in which all those luscious wines are made . . . poring over his mosquito collections, a brisk log fire on the hearth and a tiny, eggshell-thin crystal glass of Napa Rosé glowing beside him.

MOSQUITO CONTROL PEOPLE HAVE A MORBID PREOCCUPATION WITH RAINFALL SOMETIMES, BECAUSE THAT IS ULTIMATELY WHERE ALL OUR WATER COMES FROM. If rainfall is abundant but not too abundant, puddles of one size and type or another form breeding sources for mosquitoes, and if rainfall fails us, irrigation or the collection of wash waters in cisterns and catch basins come into the picture. Back in 1953, a Dr. Richard D. Hoak published some interesting information in the *Chemical and Engineering News,* which may cheer or dismay mosquitomen as they read them. "This country," he says, "does not have as wide average extremes of precipitation as occur in the rest of the world. For the world, average rainfall ranges from less than five inches in desert regions to over 450 inches on the Assam plateau. The maximum rainfall recorded in one year was 905 inches of which 366 inches fell in one month (Cherrapunji, 1861). Extremely high rates of precipitation of relatively short duration have occurred in many parts of the world. In the United States, the annual range is from less than five inches in the Southwest to 160 inches in the Pacific Northwest. The average annual rainfall for the whole country is 30 inches, of which 20 and a half inches quickly return to the atmosphere through evapotranspiration, and eight and a half inches run off to streams or percolate into the ground-water table." We can bet that little ole eight and a half inches causes more mosquito headaches than the 366 inches ever did.

LCDR JOSEPH G. MCWILLIAMS, who has been at Naval Medical Research Unit #3, in Cairo, Egypt, is receiving orders to the Disease Vector Control Center, at the Naval Air Station, Alameda, California, where he will replace CAPT. R. T. HOLWAY. Dick is going to the Armed Forces Pest Control Board, of which he will be Secretary, located at Walter Reed Army Medical Center, Washington 25, D.C., replacing Col. RALPH BUNN. We can't tell you where Ralph is going because that's a *SECRET.* (See next issue for this exciting chapter.)

WHO'S WHO this month has two members from opposite sides of the country, both of whom have appeared in our pages before, both of whom (like so many of us) were launched into their interest in mosquitoes by the Armed Forces. We had not thought to analyse this until the other day we were talking to CAPT. HOLWAY and COL. SAM DEWS and the conversation got around to how lost we had felt the first time someone stuck a dipper in our hands and we realized that *we* were supposed to come up with something. Well, the Army had COL. W. V. KING and COL. CARPENTER and the Navy had CAPT. KEN KNIGHT and the then LCDRs DICK BOHART and CHARLIE WILSON. The rest of us were still mainly interested in termites and storage insects and grasshoppers. Any of you AMCA'ers got more info on this? Write in.

COL. SAMUEL C. DEWS, BY THE WAY, HAS EXCHANGED HIS UNIFORM FOR CIVVIES and his address at the Office of the Surgeon General for the Office of the Chief of Engineers, U. S. Army, where he is assistant to DOYLE REED in their Insect and Rodent Control Section. While we're talking about him, let's add him to our WHO'S WHO and start off. Sam was born in Tonganoxie, Kansas, and went to school there, going on to the University of Kansas, where he received his AB in 1930 and his MS in 1932. As the conversation we mentioned brought out, he worked on pink boll worm, corn worm and grasshoppers and even ran a pest control business for several years. In 1940 he went to the State of Kansas as assistant to the State Entomologist, but almost at once received a red bordered letter which started off "Greetings . . ." and found his neighbors had suggested his name to the Army. A Reservist in the Sanitary Corps, Sam was assigned to Camp (later Ft.) Jackson, S. C. as entomologist and quickly won attention in the headquarters of the Fourth Service Command for his dependability, good sense and fine professional qualities, one of which was his imperturbability. (If you think *that* isn't a prime quality you have never been in the Army.) So Sam ran the entomological program of the Service Command for the duration of the war, setting up with Stan Carpenter what this Department still thinks was the finest coördination of survey and control ever practiced. It really produced results, as the many distinguished entomologists who passed through camps and stations in the seven southeastern states during the war can testify. At the close of the war, Lt. Col. Dews went to the Department of Agriculture in Gulfport, but the lure of mosquitoes proved too strong and he took the job of setting up a program for military stations in Japan under the Occupation. When Korea broke forth in a war, Sam was one of the prime movers in getting the support organized which fed trained men, materials and equipment to LT. COL. SAM HILL. Then, back in uniform, Sam D. replaced Sam H. at the end of the tour. Thereafter, back in the States, Sam (Dews) went to Ft. Bragg, and then to the Army Environmental Health Laboratory in Maryland and then to the Office of the Surgeon General. You can see he's been too busy to have hobbies, but he's no mean home carpenter and do-it-yourselfer.

MAJOR MILTON B. FLEMINGS is presently the entomologist of the First Army Medical Laboratory

and we hear that, if they have their way, he will continue to be for some time. He started, though, as a Southerner, in Fulshear, Texas, and the soft-spokenness stays with him. (He's also the traditional Texan size!) His BS was gained in 1939 from Prairie View College, Texas, his MS from Kansas State and he has gone on to further work at Rutgers. He, too, began outside mosquitodom, as a high school teacher until Uncle Sam tapped him in 1942. Starting the hard way, as a private, he became a Lieutenant in seven months. He had three overseas tours, on one of which, as a Captain in Japan, he set up a magnificent control program for an Army area located in a city noted for its sanitation problems. Milt enlisted the aid of what has since appeared in the newspapers several times as a militant citizenry. His last overseas tour was in Korea, and we guess that cured him. He is the father of a daughter who is graduating with honors from high school and who plans to enter Radcliffe next fall. His twins, who are twelve years old, a boy and a girl, are entering high school. Milt lists his hobbies as bridge (which sounds sedentary enough until you see that the other is table tennis). He has also done noteworthy work in insecticide resistance, which precludes other hobbies sometimes. He is a member of ESA, Alpha Phi Alpha, and the Agriculture Honor Society Gamma Sigma Delta.

ROBERT K. WASHINO was also turned to mosquitoes by a military start, you might say, but it was transmitted to him by Dr. Dick Bohart and ripened by the Army. He was born and raised in Sacramento, California, attended the University of California, School of Public Health, at Berkeley, and then the University of California at Davis. This is where Dick got in his licks and Bob worked under him for two years, receiving his MS degree at Davis in 1956. Soon after graduation, Bob was married and commissioned in the Army and went to basic training at Ft. Sam Houston, Texas, site of the Environmental Sanitation School. On finishing, Bob and his wife went overseas, where he was stationed at Orleans, France (some 70 miles south of Paris) for two and a half years and it was here that his son was born. Whether having a French son or having a son in the military *milieu* was the cause, we can't say, but anyhow he left right after that and came back to California to live. Here, he joined the Bureau of Vector Control and commenced work on the cooperative project jointly sponsored at Bakersfield by the BVC, the University of California (BILL REEVES) and the U.S.P.H.S. They are studying the ecology of Western equine and St. Louis encephalitis in Kern County. Bob is a member also of the ESA and the American Society of Tropical Medicine and Hygiene and his hobbies are golf and bowling and collecting mosquitoes in out of the way places. Despite the strenuousness of the first two, we suspect the last is really the most rugged of the lot. At any rate his associates comment in an awed way on his successes in it.

Watch for more information on Disneyland, "Walt Disney's Magic Kingdom," where mosquito control problems can be discussed in the shade of the Matterhorn, on the *Maid of the Mist,* while cruising down a jungle river watching the hippos attack the *Swannee Lady.* You might even see some mosquitoes from a submarine cruising through "Liquid Space," exploring the mysteries of the depths of the Seven Seas.

January 31–February 2, 1961

REVIEWS AND ABSTRACTS

HELEN LOUISE DURKEE

Handbook of Pest Control. 3rd Edition. By Arnold Mallis. 1100 pages, 250 illus., McNair-Dorland Co., New York, N. Y. 1960. Price $12.50. According to the publishers, the new, 3rd edition of "Mallis," as it is familiarly called, is the "latest and most complete book ever published on household and industrial pests and their control." This reviewer is not disposed to dispute that statement. "Mallis" has long been a byword both among pest control operators and among all entomologists who ever have occasion to give advice on the control of household insects.

The new edition with some 65 more pages, includes new methods, materials, and biological information from reference material published as late as the fall of 1959. The chapter headed "Flies, Gnats and Mosquitoes," which is selected for comment here because of its special interest to readers of this Journal, (chapter 19) comprises 138 pages, 11 more than the 2nd edition.

A comparison of a portion of the text on house flies in the two editions will serve to indicate the type of revision that has been made to bring the information presented up to date. The earlier edition mentions "vaporizers" as being emphasized in fly control, whereas the 3rd edition mentions "poisoned cords" instead, thereby acknowledging the shift in thinking on these two measures. In this chapter are three paragraphs on *Musca autumnalis* de Geer, but although it is indexed as the "face fly" it is not so identified in the text.

In the section on mosquitoes, information on encephalitis is expanded, and although some workers may feel that this section is still inadequate, it must be remembered that the book is not primarily concerned with information of this type. The section on mosquito larvicides has been enlarged by descriptions of recent developments in the use of the organic phosphate insecticides. The information on resistance is similarly brought up to date.

In general, new information is presented by insertions into the text of appropriate sentences or paragraphs rather than by the re-writing of the sections. These additions are cited in the bibliographies for the appropriate chapters. These bibliographies, as in the second edition, are a very helpful feature of the book since they enable the reader to refer to the latest source material as well as to older publications for further and more complete information.—D. L. C.

Mosquitoes of Medical Importance. By Richard H. Foote and David R. Cook. Agricultural Handbook No. 152, U. S. Dept. Agric., 158 pp., 68 figs., July, 1959. U. S. Govt. Printing Office, Washington, D. C. Price $2.50. This handbook will enable both military and civilian entomologists, especially those concerned with public health, to identify "vector" mosquitoes in any part of the world, thereby aiding in the prevention and control of mosquito-borne diseases.

The Army Medical Service first requested this research on medically important mosquitoes because of a lack of suitable guides for entomologists during World War II, when mosquito-borne diseases were a major military problem, particularly in the Pacific areas.

A unique illustrative feature of the book is a series of more than 60 pictorial keys which will aid persons having a minimum of training in identifying mosquitoes.

Arranged in three sections, the 158-page handbook first describes such diseases as malaria, yellow fever, dengue, filariasis and mosquito-borne encephalitis. It then lists and illustrates medically important mosquitoes according to geographical location, and finally gives information about known medically important species.—From a release by the Dept. of the Army.

Oviposition by Mansonioides Mosquitoes in the Gambia, West Africa. By B. R. Laurence. Proc. R. ent. Soc. Lond. (A) 34(10–12):161–170. 1959. 22 refs. 4 figs. The classical breeding places of *Mansonioides* are areas of stagnant water, covered by the floating water lettuce, *Pistia stratiotes* L. (Ingram and Macfie, 1917; Iyengar, 1938). The females lay their eggs in compact masses on the floating leaves.

Relatively little has been recorded from Africa about plants used for oviposition as alternatives to *Pistia*.

In the Gambia adult *Mansonioides* have been captured near the coast, and inland (Findlay and Davey, 1936; Bertram, McGregor and McFadzean, 1958). Descriptions of the Gambia have been given by McGregor and Smith (1952), Smithers (1956), and Bertram *et al.* (1958). The dry season is severe and lasts from November to June, most of the rains falling in the months of August and September. The annual rainfall is about 40 inches. In the dry season most freshwater areas, other than the main rivers and their tributaries dry up. During the work reported here three areas in the Gambia were visited: the country around the mouth of the River Gambia near Fajara; the tidal part of the river, about 40 miles inland around Keneba; and the freshwater part of the river, about 160 miles inland around Bansang. Most of the observations recorded here were made at Keneba, although all suitable freshwater sites here had dried up during the previous dry season. However, conditions during the rainy season appeared to be typical of much of the Gambia.

From the detailed study of the distribution of

Mansonioides egg masses on floating leaves at Keneba it appears that the females about to oviposit are first attracted to emergent vegetation standing in the water, and not to the floating leaves themselves. This may explain why, in the laboratory, gravid females have difficulty in discovering dishes containing floating leaves placed in their cages. If these females are confined in a small space over the plants, most of them will lay (Wharton, 1957; Laurence and Smith, 1958). The behaviour of *Mansonioides* in Keneba is very similar to that of *Anopheles minimus* Theobald in India, where the females select breeding places shaded by standing vegetation (Muirhead-Thomson, 1940, 1951).

Mansonioides africanus Theobald and *M. uniformis* Theobald in the Gambia are able to breed in the absence of *Pistia*. Egg masses are laid on the floating leaves of several plants, the commonest being *Nymphaea micrantha*. The position of the floating leaf relative to the surrounding vegetation is more important than leaf shape, size, or species. No egg masses were found on leaves floating in open water. The female selects breeding places containing emergent vegetation, including grasses, on the roots of which the larvae and pupae are found. The egg masses are not distributed at random between the floating leaves in these breeding places, and some leaves occupy more favorable positions for oviposition than others.

Egg masses were rare on leaves more than 12 cm. across. Most of the egg masses found on very large leaves, 16 cm. across or more, were laid through fenestrations in the leaves. This suggests that the female may fly away, without oviposition, after searching only a limited area of the leaf, if the edge is not reached during the search.

The rate of oviposition in one small area did not change markedly over a period of 14 days and there was no evidence of sudden mass oviposition. There was no difference in the numbers of egg masses laid on floating leaves in unweeded rice fields, and on leaves floating amongst the emergent vegetation of small pools. Clearance of rice swamps reduces the breeding area of *Mansonioides*, whereas unweeded rice fields are foci for breeding.—Excerpts from text, discussion, and summary.

KAIRI VIRUS, A NEW VIRUS FROM TRINIDADIAN FOREST MOSQUITOES. By C. R. Anderson, T. H. G. Aitken, L. P. Spence, and W. G. Downs. Amer. J. trop. Med. Hyg. 9(1):70–72. 1960. During the course of arthropod-borne virus investigations in Trinidadian forests in 1955, 31 viruses were isolated in baby mice from mosquitoes taken while attacking human bait. Of these, 27 came from the Melajo Forest, 7-1/2 miles from Sangre Grande in the northeastern part of the island. Ten of the Melajo agents have been shown to be strains of the same virus, a virus which is apparently new to science and for which the name "Kairi" (meaning "island" in Carib dialect) is proposed. An eleventh strain of the same virus was recovered in 1958 from the Archer Estate near Rio Claro in South Trinidad.

Four of the strains came from pools of *Aedes scapularis*, four from *Wyeomyia* pools (including *W. aporonoma* and *W. ypsipola*), two from pools of *Psorophora ferox*, and one from *Culex spissipes*. A total of 2,838 mosquitoes was used.

The mosquitoes were ground with alundum in a mortar and suspended in 2 ml. of diluent, with the exception of the two *P. ferox* pools, which were suspended in 3 ml. (The diluent employed was phosphate buffered 0.75 percent bovalbumin in normal saline which contained 400 units of penicillin and 250 μg of streptomycin per ml. This diluent was sterilized by Seitz filtration.) The suspension was then centrifuged for one-half hour in an angle centrifuge at about 8,000 rpm in a 4° C. cold room. The supernatant was inoculated intracerebrally into a group of 2-day old mice. An aliquot was stored in a sealed glass ampoule in the CO_2 ice chest.—Excerpts from text.

FUNCTIONAL AND MORPHOLOGICAL ADAPTATIONS OF THE LARVAL MOUTHPARTS IN THE SUB-FAMILY CULICINAE (DIPTERA) WITH A REVIEW OF SOME RELATED STUDIES BY MONTSCHADSKY. By G. Surtees. Proc. R. ent. Soc. Lond. (A) 34(1–3):7–16. 1959. 9 refs. 5 figs. The larvae of the subfamily Culicinae are divided into three classes of feeders, termed filter feeders, browsers, and predators; each of these terms is defined. The filter feeders are characterized by long, fine, unserrated mouth-brushes, large maxillae, and weakly chitinized mandibles. The browsers have shorter mouth-brushes, serrated distally, whilst the maxillae are smaller and the mandibles stronger. The predators have a few strong mouth-brushes, strongly chitinized mandibles and reduced maxillae. Series of species are described, extending from the filter feeders to the predators.

The work of Montschadsky (1936) is reviewed and discussed in the light of these new observations. Ground pools are discussed as the primitive larval environment and tree-hole dwelling browsers as the precursors of the present predatory species.

It may be concluded that those species which are filter feeders are the more primitive, whilst those which have developed more complex feeding habits and have colonized other environments are the more recent. Similarly, those genera in which there are a greater variety of feeding habits will have a greater potentiality for colonizing new habitats, and so the spread of the existing species and the selection of new ones will be facilitated, a situation which will be intensified in those species showing sub-specific variations.—Excerpts from author's discussion and summary.

ON THE DISTRIBUTION AND SEASONAL INCIDENCE OF CULICINE MOSQUITOES IN SOUTHERN NIGERIA. By G. Surtees. Proc. R. ent. Soc. Lond. (A)

34(7–9):110–120. 1959. 21 refs. Mosquito investigations carried out in an isolated village in Southern Nigeria comprised a survey of the natural larval habitats and studies on the distribution and the seasonal incidence of the major species. It was found that *Aedes aegypti* was largely restricted to domestic containers in the village, *A. longipalpis* to tree holes in the rain forest, *Eretmopodites chrysogaster* to cocoa husks in the cocoa plantation, *Harpagomyia taeniarostris* to leaf axils, and *Eretmopodites pencillatus* to snail shells. Other species had a more plastic breeding pattern. A succession of species was shown to exist from the village, through scrub into the forest, consisting of *A. aegypti, A. apicoargenteus, Culex nebulosus, Megarhinus brevipalpis, E. chrysogaster, Culex albiventris, A. longipalpis,* and *A. simulans.*

The numbers of larvae increased at the beginning of the rainy season, declined in the mid-rainy season (June and July) and built up again in August, before a final drop at the end of the rainy season.

The coincidence between the natural classification of breeding sites and the species found therein, as postulated by Shannon (1931), is discussed and is shown to hold for only a few of the species described here. The plasticity of breeding behaviour is discussed.

The pattern of distribution in this area is considered to be determined by a combination of factors, including those relating to the habitats of the larvae and the food sources of the adult females. It is further suggested that the mid-year drop in numbers is a population density reaction, because it was found that under controlled conditions the greater the density of larvae the higher the mortality and the longer the developmental period.—Author's summary.

Malaria as a World Wide Problem and Method of Eradicating Malaria in the USSR. By P. G. Sergiev, M. G. Rashina and A. Ya. Lysenko. Med. Parasitol. i Parasit. Boles., Tome XXXVII, n. 3, 268–280, May–June, 1959. This paper is a résumé of data on the world-wide distribution of malaria as of 1958, and a statement of the results of malaria eradication attempts in the USSR. There is practically no description of the methods used, but apparently only DDT house residual spraying is attempted.

The general claim is made that in the Soviet Union malaria has been reduced in recent years to such a low level that it is now on the brink of complete extirpation. However, it is apparent from the data presented, and from direct admissions in the article, that in considerable areas in many republics the program "has not been changed toward the side of extinction." These areas appear to be mainly in the republics, such as Azerbaidzhan, Georgia, Uzbek, Yakutz, etc., in the southerly and southeasterly parts of the USSR. The areas in which the nearest approach to eradication has been attained are in the conquered nations of Latvia, Esthonia and Lithuania in the northwest, and in Byelorussia, Russia proper, and the Ukraine. The impression gained from the article is that in relation to malaria Russia is about where the United States was in the 1920's.

Complaint is made of concealment or non-reporting of both clinical and non-symptomatic cases, of migration of missed cases from infected areas into non-infected areas both within and without the Soviet Union (Communist China and Iran being specially noted as such exterior sources), and of flights of infected mosquitoes from one area to another. The latter appears to be dubious and of miniscule effect in disease transmission as compared with the migration of infected humans.

Another complaint voiced is that in many districts the eradication methods have not been carried out thoroughly, due to the indifference or inefficiency of the control personnel. It is also stated that there has been failure in some sections to reduce control measures proportionately where indicated by practically complete extirpation of the disease.

An interesting facet of the paper is a statement that there is a "certain uneasiness" that in the southern republics there is a higher proportion of cases in the second half as compared with the first half of the year. This is precisely what has been the epidemiological pattern in northern hemisphere areas, with but few exceptions, and it is difficult to understand why a normal condition should inspire "uneasiness." Possibly the difficulty lies in translation.

The paper is to be commended for its viewpoint that Russia should cooperate in the world wide eradication campaign for its own benefit if for no other reason.—Harold F. Gray, Oroville, Calif.

REFERENCES TO LITERATURE OF INTEREST TO MOSQUITO WORKERS AND MALARIOLOGISTS

HELEN SOLLERS
Plant Pest Control Division, Agricultural Research Service, United States Department of Agriculture, Washington 25, D. C.

ADULTICIDES AND LARVICIDES

ABDULLAEV, KH. I. 1959. Efficacy of short-term malaria chemoprophylaxis with pyrimethamine and treatment of dwellings with DDT in highly endemic malaria regions. *In* Trudy Instituta. pp. 233–239, Moscow. In Rus.

——. 1959. Efficacy of DDT and BHC preparations in the treatment of dwellings in regions where *A. superpictus* predominates. *In* Trudy Instituta. pp. 225–232, Moscow. In Rus.

BLÁZQUEZ, J. 1959. The residual insecticidal effect of Bayer Compound S-1752 (Bayer 29 493) in laboratory tests. Jour. Econ. Ent. 52(6):1096–1099. [Includes mosquitoes.]

CHOUMARA, R., HAMON, J., ADAM, J. P., RICOSSE, J. and BAILLY, H. 1959. Le paludisme dans la zone pilote antipaludique de Bobo Dioulasso (Haute Volta). Étude faite au centre Muraz de Bobo Dioulasso. Cahiers de l'O.R.S.T.O.M. No. 1, 125 pp. Fr., Engl, Span., Ger. Sum.

COMMUNICABLE DISEASE CENTER. USPHS. 1960. 1960 report public health pesticides. Pest Control 28(3):9–10, 12, 14–16, 18, 20, 22–24, 26, 28–29. [Includes mosquito control.]

DAVIS, A. N. 1959. Laboratory tests with organic compounds against adult salt-marsh mosquitoes. N. J. Mosquito Extermin. Assoc. Proc. 46:186–188.

EDMUNDS, L. R. and BLAKESLEE, T. E. 1959. Intensive limited area control of potential arthropod disease vectors. Jour. Econ. Ent. 52(9):1050–1053. [Includes mosquitoes.].

GINSBURG, J. M. 1959. New Jersey's contribution to mosquitocides, past and future. N. J. Mosquito Extermin. Assoc. Proc. 46:125–133.

GRAHAM, J. E. 1959. The relation of detailed larval surveys to control efficiency in Salt Lake County. N. J. Mosquito Extermin. Assoc. Proc. 46:119–121.

JUNG, H. F. 1959. A new phosphoric ester residual insecticide with a low order of toxicity. WHO Bul. 21(2):215–221.

LOPP, O. V. and BUCHANAN, W. J. 1959. Some further observations on the pre-emergence antilarval program of the South Cook County Mosquito Abatement District. N. J. Mosquito Extermin. Assoc. Proc. 46:192–196.

MILLER, T. W., JR. 1959. How we converted our Tifas from gasoline to propane. Pest Control 27(12):14, 16, 18.

PETRISCHEVA, P. A., SAFIANOVA, V. M., GAIKO, B. A. and NEFEDOV, D. D. 1960. Background for measures to control blood sucking mosquitoes of the genus *Aedes*. Med. Parazit. i Parazit. Bolezni 29(1):57–60. In Rus., Engl. Sum.

RATHBURN, C. B., JR. and ROGERS, A. J. 1959. Field tests of mists and dusts against caged adults of *Aedes taeniorhynchus* (Wied.). N. J. Mosquito Extermin. Assoc. Proc. 46:200–205.

ROGERS, A. J. and RATHBURN, C. B., JR. 1960. Improved methods of formulating granular paris green larvicide. Mosquito News 20(1):11–14.

VOELCKEL, J. and MOUCHET, J. 1959. Quelques aspects et résultats de la désinsectisation systématique en milieu urbain tropical. Méd. Trop. (Marseilles) 19(3):266–293.

WEIDHAAS, D. E. and SCHMIDT, C. H. 1960. Toxicological action of DDT on three species of mosquito larvae. Jour. Econ. Ent. 53(1):106–110.

—— and BOWMAN, M. C. 1960. Effects of heterogeneous distribution and codistillation on the results of tests with DDT against mosquito larvae. Jour. Econ. Ent. 53(1):121–125.

VARIOUS TYPES OF CONTROL

EDMAN, J. 1960. Mosquito study Lewis and Clark Reservoir summer of 1959. Nebraska State Dept. Health, Div. of Sanit. 8 pp., illus. Lincoln, Nebraska.

METROPOLITAN DADE COUNTY. Public Works Department. Mosquito Control Division. 1959. 1959 annual report. 15 pp., Miami, Florida.

REMMENGA, A. 1960. Mosquito control in the Twin Cities. Pest Control 28(4):9, 11–12, 14, 16, 18.

CONTROL PAPERS FROM N. J. MOSQUITO EXTERMIN. ASSOC. PROC. 46:

BUZICKY, A. W. 1959. Obligations of the personnel in the establishment and operation of a mosquito control commission. Part II. As viewed by an administrative director. pp. 71–73.

COLLETT, G. C. and REES, D. M. 1959. Mosquito abatement programs in Utah in 1958. pp. 61–63.

COMISKI, W. 1959. What the mosquito control short course has meant to me. pp. 208–210.

DILLISTIN, W. H. 1959. Activities of the State Mosquito Control Commission. pp. 12–16.

DORER, R. E. 1959. Thoughts to think about. pp. 153–155.

HELM, R. W. 1959. Disappearing meadowland in Union County. pp. 74–77.

MACDONALD, J. C. 1959. Mosquito control as related to recreational use in southern New Jersey. pp. 111–118.

MATTHEWS, G. W. 1959. Obligations of the personnel in the establishment and operation of a mosquito control commission. Part I. As viewed by a commissioner. pp. 70–71.

MCDUFFIE, W. C., GAHAN, J. B. and DAVIS, A. N. 1959. Highlights of mosquito control research by the Entomology Research Division. pp. 52–56.

METZGER, K. E. 1959. Mosquito control problems in relation to metropolitan development. pp. 189–192.

PERILLI, M. T. 1959. Medium and long range planning by mosquito commissions. pp. 206–208.

ROSS, T. E. 1959. Considerations in the procurement and training of mosquito commission personnel. pp. 155–157.

STARNES, O. 1959. New Jersey agriculture and its relation to mosquito control. pp. 7–12.

TRAVIS, J. H. 1959. Mosquito control in Bermuda. pp. 158–160.

WELSH, J. T. 1959. The value of mosquito control in Bucks County, Pennsylvania. pp. 138–139.

ZEMLANSKY, J. 1959. Sanitary landfills and their application to mosquito control. pp. 210–213.

PARASITES AND PREDATORS

CHAO, J. and WISTREICH, G. A. 1959. Microbial isolations from the mid-gut of *Culex tarsalis* Coquillett. Jour. Insect. Path. 1(4):311–318.

COSGROVE, W. B. 1959. Utilization of carbohydrates by the mosquito flagellate, *Crithidia fasciculata*. Canad. Jour. Microbiol. 5(6):573–578.

LAIRD, M. 1959. Biological solutions to problems arising from the use of modern insecticides in the field of public health. Acta Tropica 16(4): 331–355. Fr., Ger. Sum.

———. 1959. Fungal parasites of mosquito larvae from the Oriental and Australian Regions, with a key to the genus *Coelomomyces* (Blastocladiales: Coelomomycetaceae). Canad. Jour. Zool. 37(5):781–791.

MAFFI, M. 1959. Ancora sul *Coelomomyces* Keilin, 1921, in Somalia. Riv. di Malariol. 38 (4/6):260. Illus.

SMITH, D. L. 1960. The ability of the top minnow, *Gambusia affinis* (Baird and Girard) to reproduce and overwinter in an outdoor pond at Winnipeg, Manitoba, Canada. Mosquito News 20(1):55–56.

ATTRACTANTS AND REPELLENTS

BATAEV, P. S. and COWORKERS. 1959. Chemical structure and repellent activity. Research on repellent activity among substitute amides, carbon acids, ethers and glycols. *In* Trudy Instituta. pp. 354–380, Moscow. In Rus. [Includes mosquito repellents.]

GOUCK, H. J. and BOWMAN, M. C. 1959. Effect of repellents on the evolution of carbon dioxide and moisture from human arms. Jour. Econ. Ent. 52(6):1157–1159. [Includes *Aedes aegypti*.]

GRANETT, P. and STARNES, E. B. 1960. Screening chemical repellents. Chap. VIII. *In* Shepard, H. H. (Ed.). Methods of testing chemicals on insects. Vol. II. pp. 101–119. Minneapolis, Minn. [Includes mosquitoes.]

RAKHMANOVA, P. I. 1959. On the method of field investigation on the efficacy of repellents against blood sucking mosquitoes. *In* Trudy Instituta. pp. 381–388, Moscow. In Rus.

RESISTANCE AND SUSCEPTIBILITY

ACOSTA, M. 1958. Niveles basicos de susceptibilidad del *Anopheles pseudopunctipennis* al DDT y al dieldrin en la region occidental del Peru. Rev. Med. Expt. (Lima) 12(1/2):99–106. Engl. Sum.

BROWN, A. W. A. 1959. Inheritance of insecticide resistance and tolerance. Ent. Soc. Amer. Misc. Publ. 1(1):20–26. [Includes mosquitoes.]

———. 1960. Mechanisms of resistance against insecticides. Ann. Rev. of Entomology Vol. 5: 301–326, Palo Alto, Calif. [Includes mosquitoes.]

BUSVINE, J. R. 1959. The detection and measurement of insecticide resistance. Internatl. Cong. Zool. Proc. 15:499–502.

COLUZZI, A. 1959. Sensibilità al D.D.T. di alcune species anofeliniche in Sardegna e in Italia continentale. Riv. di Malariol. 38(4/6):237–239. Engl. Sum.

DARSIE, R. F., JR. and SUTHERLAND, D. W. S. 1959. Evidence of resistance to BHC in adults and larvae of *Aedes sollicitans* in Delaware during 1958. N. J. Mosquito Extermin. Assoc. Proc. 46: 84–94.

DARVAS, A. and SERSTNEV, E. 1959. The reduced sensitivity of *Anopheles maculipennis* to DDT in some regions of Bosnia and Herzegovina. The sensitivity of *Anopheles* to dieldrin and lindane. Higijena (Belgrade) 11(1):17–22. In Yug., Fr. Sum.

DAVIS, A. N., WEIDHAAS, D. E. and FORD, H. R. 1959. Relative susceptibility of salt-marsh mosquitoes from Georgia and Florida to insecticides. Fla. Ent. 42(3):109–111.

ELLIOTT, R. 1959. Insecticide resistance in some *Anopheles* larvae. Indian Jour. Malariol. 13(1): 7–11.

FAY, R. W. 1959. Insecticide resistance in *Aedes aegypti*. N. J. Mosquito Extermin. Assoc. Proc. 46:180–185.

MALDONADO-CAPRILES, J. and NASIR, A. S. 1960. DDT-resistant adults of *Anopheles subpictus* in the Lahore district of West Pakistan. Mosquito News 20(1):52–54.

MARIANI, M., MARCECA, G., ODDO, F. and TERMINELLO, L. 1959. Ulteriori indagini sulla sensibilità al DDT dell'*Anopheles labranchiae* in Sicilia. Riv. di Parassitol. 20(3):191–198. Engl. Sum.

MARTÍNEZ PALACIOS, A. 1959. Ecologia y resistencia. CNEP Bol. (Mexico) 3(1):38–40. Engl. Sum.

NERI, I., ASCHER, K. R. S. and MOSNA, E. 1959. Studies on insecticide-resistant anophelines. 5. Lipoid content of female *Anopheles atroparvus*. WHO/Mal/249, WHO/Insect./105, 8 pp.

RACHOU, R. G., MOURA LIMA, M. and LEAL, J. M. 1959. Grau de suscetibilidade do *Anopheles (Nyssorhynchus) darlingi* ao DDT em duas

localidades do Estado de Minas Gerais (Brasil). Rev. Brasil. de Malariol. 11(1):67–70. Engl. Sum.

SCHOOF, H. F. 1959. Resistance in arthropods of medical and veterinary importance—1946–1958. Ent. Soc. Amer. Misc. Pub. 1(1):3–11.

SEN, PURNENDU. 1959. Studies on insecticide resistance in insects of public health importance in West Bengal, India. Indian Jour. Malariol. 13 (1):19–33.

SMITH, A. 1959. Results of screening *Anopheles gambiae* for resistance to dieldrin in the Pare area of north-east Tanganyika. WHO Bul. 21(2):239–240.

WEINBURGH, H. B. and FAY, R. W. 1960. Colonization and production of a dieldrin-resistant strain of *Anopheles quadrimaculatus* Say. Jour. Econ. Ent. 53(1):101–103.

YAGUZHINSKAYA, L. V. 1959. Resistance to DDT (dichloro diphenyl trichloroethane) of insects with different temperature requirements. *In* Trudy Instituta. pp. 342–353, Moscow. In Rus. [*Aedes* and *Anopheles* included.]

INSECTICIDES AND CHEMICALS

COMMONWEALTH INSTITUTE OF ENTOMOLOGY. 1960. The nomenclature of chemicals used in pest control. Rev. Appl. Ent. Ser. B. 48(1):1–7.

SHEPARD, H. H. (Editor). 1960. Methods of testing chemicals on insects. Vol. II. 248 pp., Minneapolis, Minnesota.

WEIDHAAS, D. E., GAHAN, J. B. and FORD, H. R. 1959. Effect of temperature, aeration, pH, and the presence of soil on the toxicity of various insecticides to mosquito larvae. Fla. Ent. 42(3): 105–108.

TOXICOLOGY

BURKATZKAYA, E. N. and COWORKERS. 1959. Working hygiene and the state of health of workers producing insecticides containing BHC. Gigiena i Sanit. (Moscow) 24(5):17–22. In Rus. [Engl. sum in WHO Inform. Cir. No. 4, 1960, on Toxicity of pesticides to man.]

HAYES, W. J., JR. 1960. Pesticides in relation to public health. Ann. Rev. of Entomology. Vol. 5:379–404, Palo Alto, Calif.

VENGERSKAYA, KH. YA. and COWORKERS. 1959. Working conditions during application of organic phosphate insecticides. Gigiena i Sanit. (Moscow) 24(5):12–17. In Rus. [Engl. Sum. in WHO Inform. Cir. No. 4, 1960, on toxicity of pesticides to man.]

WORLD HEALTH ORGANIZATION. 1960. Bibliography of pesticides toxicity and accidental poisoning. WHO/Insect./107, 6 pp.

———. 1960. Information circular on the toxicity of pesticides to man. Vect. Cont. and Pesticides, Div. of Environm. Sanit. (WHO) Cir. No. 4, 15 pp.

BEHAVIOR, BIOLOGY AND ECOLOGY

BARR, A. R., JUDSON, C. L. and ROSAY, B. 1959. The egg stage of aedine mosquitoes: its natural history and susceptibility. N. J. Mosquito Extermin. Assoc. Proc. 46:77–83.

BARRERA, A., HECHT, O. and MANCERA, O. 1959. Estimacion cuantitativa de la excitacion producida por el contacto con superficies tratadas con DDT, en tres especies de anofelinos Mexicanos. Riv. di. Malariol. 38(4/6):213–236. Engl. Sum.

BECKEL, W. E. and ATWOOD, H. L. 1959. A contribution to the bionomics of the mosquitoes of Algonquin Park. Canad. Jour. Zool. 37(5): 763–770.

BURGESS, L. 1959. Probing behaviour of *Aedes aegypti* (L.) in response to heat and moisture. Nature (London) 184(4703):1968–1969.

CHOW, C. Y., IBNOE, R. M. and JOSOPOERO, S. T. 1960. Bionomics of anopheline mosquitoes in inland areas of Java, with special reference to *Anopheles aconitus* Dön. Bul. Ent. Res. 50(4): 647–660.

DERGACHEVA, T. I. 1959. Adaptation of mosquitoes to varying air humidity. Akad. Nauk SSSR Dok. 129(2):431–434. In Rus.

EADS, R. B., FOYLE, J. G. and PEEL, R. E. 1960. Mosquito densities in Orange County, Texas. Mosquito News 20(1):49–52.

FERRIGNO, F. 1959. Further study on mosquito production on the newly acquired Cadwalader Tract. N. J. Mosquito Extermin. Assoc. Proc. 46: 95–102.

FLORSCHUTZ, O., JR. 1959. Mosquito production and wildlife usage in impounded, ditched and undiched tidal marshes at Assawoman Wildlife Area, Delaware 1957–58. N. J. Mosquito Extermin. Assoc. Proc. 46:103–111.

GILLETT, J. D. 1959. Mosquito catches in Lunyo Forest. East Afr. Virus Res. Inst. Rpt. 9:34–35.

GRACHEVA, L. I. and SHEVKUNOVA, E. A. 1959. Materials on the study of bloodsucking mosquitoes in the south of the Archangelsk region. Zool. Zhur. 38(11):1751–1753. In Rus., Engl. Sum. [Chiefly *Aedes*.]

HADDOW, A. J. 1959. Analysis of 24-hour mosquito catches. East Afr. Virus Res. Inst. Rpt. 9:38.

———. 1959. Mosquito catches in the Mpanga Forest with man as bait. East Afr. Virus Res. Inst. Rpt. 9:30–33.

———. 1960. Studies on the biting habits and medical importance of East African mosquitos in the genus *Aedes*. I. Subgenera *Aedimorphus, Banksinella* and *Dunnius*. Bul. Ent. Res. 50(4): 759–779.

——— and CORBET, P. S. 1959. Observations on the swarming of male mosquitoes and tabanids at the tower in Mpanga Forest. East Afr. Virus Res. Inst. Rpt. 9:27–29.

IVANOVA, L. V. 1959. Regularity of distribution of *Anopheles maculipennis* in settlements depending on the topography and prevailing winds. *In* Trudy Instituta. pp. 240–292, Moscow. In Rus.

KUHLOW, F. 1959. On the behaviour of *Anopheles funestus* in unsprayed and DDT sprayed

houses. Ztschr. f. Tropenmed. u. Parasitol. 10(3): 328–333. In Engl.

McCLELLAND, G. A. H. 1959. The biting cycle of *Ae. aegypti*. Final results of studies to determine hosts attacked in nature by *Ae. aegypti* and other mosquitoes. Further behavioral differences between strains of *Ae. aegypti*. Studies on oviposition of mosquitoes in the field by the use of bamboo pots. East Afr. Virus Res. Inst. Rpt. 9:39; 39–40; 41; 41–42. [The above includes 4 separate articles.]

———. 1960. Observations on the mosquito *Aedes (Stegomyia) aegypti* (L.) in East Africa. II. The biting cycle in a domestic population on the Kenya Coast. Bul. Ent. Res. 50(4):687–696.

MELLANBY, K. 1960. Acclimatization affecting the position of the cold and heat death points of larvae of *Aedes aegypti* (L.) Bul. Ent. Res. 50(4): 821–823.

MENON, M. A. U. and TAMPI, M. R. V. 1959. Notes on the feeding and egg-laying habits of *Ficalbia (Mimomyia) chamberlaini*, Ludlow 1904. (Diptera, Culicidae). Indian Jour. Malariol. 13(1): 13–18.

PRATT, H. D. 1959. A new classification of the life histories of North American mosquitoes. N. J. Mosquito Extermin. Assoc. Proc. 46:148–152.

PROVOST, M. W. 1959. Current research in mosquito biology and control at Florida's Entomological Research Center. N. J. Mosquito Extermin. Assoc. Proc. 46:64–70.

SCHREIBER, G. and GUEDES, A. S. 1959. Cytological and ecological researches on Brazilian anophelids. Internatl. Cong. Zool. Proc. 15:755–756. Also in Rev. Brasil. de Malariol. 11(1): 97–98.

SHLENOVA, M. F. 1959. Seasonal variation in the number of mosquitos of the genus *Aedes* in the environs of Moscow. *In* Trudy Instituta. pp. 304–315, Moscow. In Rus.

SMITH, A. and WEITZ, B. 1959. The feeding habits of *Anopheles gambiae* with particular reference to subsidiary hosts. Ann. Trop. Med. and Parasitol. 53(4):414–415.

SNOW, W. E. and CORBET, P. S. 1959. Studies on movements of mosquitoes at sunset. East Afr. Virus Res. Inst. Rpt. 9:38–39.

STEYN, J. J. and COWORKERS. 1959. Dragtigheids-data van *Anopheles gambiae* Giles en malariauitwissing in die Transvaal. South Afr. Med. Jour. 33(33):679–680.

SURTEES, G. 1960. The breeding behaviour of the type form of *Aedes (Stegomyia) aegypti* (L.) in south-western Nigeria in relation to insecticidal control. Bul. Ent. Res. 50(4):681–686.

See also Christophers under Yellow Fever.

GENETICS

CRAIG, G. B., JR. and GILHAM, N. W. 1959. The inheritance of larval pigmentation in *Aedes aegypti*. Jour. Heredity 50(3):115–123.

McCLELLAND, G. A. H. 1959. Preliminary genetic studies on *Ae. aegypti* from Ganda, Kenya. East Afr. Virus Res. Inst. Rpt. 9:40.

TECHNIQUES

AFRIDI, M. K., TALIBI, S. A., RASHID, S. A. and HUSAIN, M. Z. Y. 1958. Identification of races of *A. stephensi* prevalent in the Federal Karachi Area by measurement of their ova. Pakistan Jour. Health 8(2):71–76.

ANDERSON, P. K., MOORE, J. B. and SMITH, G. E. 1960. An improved diet for insectary rearing of *Anopheles quadrimaculatus* Say. Mosquito News 20(1):57–58.

BEKLEMISHEV, W. N., DETINOVA, T. S. and POLOVODOVA, V. P. 1959. Determination of physiological age in anophelines and of age distribution in anopheline populations in the USSR. WHO Bul. 21(2):223–232.

CORBET, P. S. 1959. Dissection of mosquito ovaries to determine age. Age-grading by external characters in mosquitoes. Studies on age-composition of mosquito populations in Mpanga Forest. Seasonal changes in age-composition of mosquito populations. East Afr. Virus Res. Inst. Rept. 9:36; 36–37; 37; 37–38. [The above includes 4 separate articles.]

FRITZ, R. and PLETSCH, D. J. 1959. A practical device for weighing insecticides in malaria eradication programmes. WHO Bul. 21(2):211–214.

GEIB, A. F. and ISAAK, L. W. 1960. A simple method for determining airplane swath pattern. Mosquito News 20(1):55.

GILLETT, J. D. 1959. Control of hatching in the prediapause eggs of *Aedes* mosquitoes. Nature (London) 184(4699):1621–1623.

——— and McCLELLAND, G. A. H. 1959. Mosquitoes. East Afr. Virus Res. Inst. Rpt. 9:47. [Rearing strains of *Aedes aegypti*.]

HADDOW, A. J., GILLETT, J. D. and CORBET, P. S. 1959. The steel tower in Mpanga Forest. East Afr. Virus Res. Inst. Rpt. 9:23–25.

KILLOUGH, R. A. 1959. A storage rack for insect specimens preserved in liquids. Jour. Econ. Ent. 52(6):1225–1226.

LEBIED, B. 1959. Détermination de l'age physiologique des diptères. Nouvelle méthode basée sur la recherche des vestiges du processus de l'ovulation. Riv. di Parassitol. 20(2):91–106.

LÓPEZ ANTUÑANO, F. J. 1959. Microscopia en la malaria humana. CNEP Bol. (Mexico) 3(1) (Suppl):1–28.

MAFFI, M. 1959. Su un nuovo simbolismo grafico per la rappresentazione della distribuzione geografica dei vettori, con particolare riguardo alle anofele in Africa Equatoriale. Riv. di Malariol. 38(4/6):241–250. Engl. Sum.

MARCOVITCH, S. 1960. Experiments on prolongation of the life of mosquito larvae by underfeeding. Jour. Econ. Ent. 53(1):169.

McLINTOCK, J. 1960. Simplified method for maintaining *Culex pipiens* Linnaeus in the laboratory (Diptera: Culicidae). Mosquito News 20(1): 27–29.

POLLARD, D. G. 1960. A cage suitable for holding and feeding blood-sucking mosquitoes. Mosquito News 20(1):56–57.

ROMERO ALVAREZ, H. and MIRANDA FRANCO, R. 1959. Measurement of insecticides for house spraying. WHO Bul. 21(2):207–210.

WELCH, H. E. and JAMES, H. G. 1960. The Belleville trap for quantitative samples of mosquito larvae. Mosquito News 20(1):23–26.

WILLIAMS, P. 1959. The effect of atmospheric pressure on *Aedes aegypti* exposed to *Dirofilaria immitis* and on *Glossina morsitans* exposed to *Trypanosoma rhodesiense* or *T. congolense*. Ann. Trop. Med. and Parasitol. 53(4):451–464.

WOODALL, J. P. 1959. Attempt to culture *Aedes apicoargenteus* in the laboratory. East Afr. Virus Res. Inst. Rpt. 9:47–48.

ANATOMY, MORPHOLOGY AND PHYSIOLOGY

ASSEM, J. VAN DEN. 1959. Daily mortality in four species of New Guinea anophelines. Trop. and Geog. Med. 11(3):223–236.

GALUN, R. 1960. Respiration of decapitated mosquitoes. Nature (London) 185 (4710):391–392.

LAMBREMONT, E. N. 1960. Postemergence changes of enzyme activity in the mosquito, *Aedes aegypti* (L.). Ent. Soc. Amer. Ann. 53(1):86–91.

LILES, J. N. and DELONG, D. M. 1960. The longevity and productivity of adult male and female *Aedes aegypti* when reared separately and together on three different diets. Ent. Soc. Amer. Ann. 53(2):277–280.

PEÑA DE GRIMALDO, E. and LAVOIPIERRE, M. M. J. 1959. Puesta al día de los últimos adelantos sobre la aridez por sangre de los mosquitos *Aedes aegypti* variedad *queenslandensis*. Rev. Ibérica de Parasitol. 19(4):417–425.

RAPP, W. F., JR. 1960. Notes on the chemical conditions in the mosquito larval environment. Mosquito News 20(1):29–30.

STOBBART, R. H. 1959. Studies on the exchange and regulation of sodium in the larvae of *Aedes aegypti* (L.). Jour. Expt. Biol. 36(4): 641–653.

VAN DER KLOOT, W. G. 1960. Neurosecretion in insects. Ann. Rev. Entomology Vol. 5:35–52, Palo Alto, Calif.

See also Beklemishev, Detinova and Polovodova; Gillett; Marcovitch under Techniques; and Christophers under Yellow Fever.

TAXONOMY

ASSEM, J. VAN DEN. 1959. Notes on New Guinean species of *Tripteroides*, subgenus *Rachisoura* (Diptera, Culicidae), with descriptions of two new species. Tijdschr. v. Ent. 102(1):35–55. [*T. cuttsi* and *T. adentata* sp. n.]

BARR, A. R. 1960. A review of recent findings on the systematic status of *Culex pipiens*. Calif. Vector Views 7(3):17–21.

BRADLEY, C. L. and POST, R. L. 1960. Keys to the more common North Dakota mosquitoes with comments on their biology and distribution. N. Dak. Assoc. of Sanitarians Newsletter Appendix (Mar.):1–9.

CORRÊA, R. R. and RAMALHO, G. R. 1959. Descrição de uma nova espécie de *Culex* (Diptera, Culicidae). Rev. Brasil. de Malariol. 11(1):55–57. [*C. forattinii*.]

CRAIG, G. B., JR. and HORSFALL, W. R. 1960. Eggs of floodwater mosquitoes. VII. Species of *Aedes* common in the southeastern United States (Diptera: Culicidae). Ent. Soc. Amer. Ann. 53(1): 11–18.

GUY, Y. 1959. Les Anopheles du Maroc. Soc. Sci. Nat. et Phys. Mem. n. s. Zool. 7, 235 pp., Maroc.

MATTINGLY, P. F. 1959. The culicine mosquitoes of the Indomalayan Area. Part IV. Genus *Aedes* Meigen, subgenera *Skusea* Theobald, *Diceromyia* Theobald, *Geoskusea* Edwards, and *Christophersiomyia* Barraud. 61 pp. (Brit. Mus. (Nat. Hist.)). [*Aedes celebicus, A. franciscoi, A. gombakensis* sp. n.]

PETERS, W. 1959. Mosquitoes of New Guinea (Diptera: Culicidae). Part II. Notes on *Tripteroides* Giles, 1904. Roy. Ent. Soc. London Proc. Ser. B. 28(9/10):135–154. [*T. leei, T. standfasti* sp. n.]

QUTUBUDDIN, M. 1959. A new species of *Aedimorphus* (Diptera: Culicidae) from Sudan Republic. Ann. and Mag. of Nat. Hist. Ser. 13, 2(13):21–23. [*Aedes mansouri* sp. n.]

DISTRIBUTION

LIPS, M. 1959. *Anopheles* du Congo Belge. 1. Espèces particulières du Katanga. References. Recoltes. Repartition et importance medicale actuelle. Riv. di Parassitol. 20(3):165–189. Engl. Sum.

MCCLELLAND, G. A. H. 1959. Visit to Kaimosi Forest, Kenya. East Afr. Virus Res. Inst. Rpt. 9:35–36.

ODDO, F. 1959. Anofelini de massiccio delle Madonie. Riv. di Malariol. 38(4/6):251–259. Engl. Sum.

SHEMANCHUK, J. A. 1959. Mosquitoes (Diptera: Culicidae) in irrigated areas of southern Alberta and their seasonal changes in abundance and distribution. Canad. Jour. Zool. 37(6):899–912.

SURTEES, G. 1959. On the distribution and seasonal incidence of culicine mosquitoes in Southern Nigeria. Roy. Ent. Soc. London Ser. A. Proc. 34(7/9):110–120.

See also Assem, Mattingly, Peters and Guy under Taxonomy.

ENCEPHALITIS

BENNINGTON, E. E. and SHERMAN, I. L. 1960. A note on reported cases of encephalitis and soil temperatures in Colorado. Mosquito News 20(1): 34–38.

HESS, A. D. and BEADLE, L. D. 1959. Present status of encephalitis in the Western States. N. J. Mosquito Extermin. Assoc. Proc. 46:196–200.

IRONS, J. V., EADS, R. B., GRIMES, J. E. and SULLIVAN, T. D. 1960. Investigación sobre la encefalitis en Texas. Bol. Ofic. Sanit. Panamer. 48(1):61–63.

JOHNSON, H. N. 1960. Ecología de las enfermedades virales del hombre transmitidas por artrópodos. Bol. Ofic. Sanit. Panamer. 48(2):134–140. Engl. Sum. [Mosquitoes and encephalitis.]

KARSTAD, L. and HANSON, R. P. 1959. Natural and experimental infections in swine with the virus of eastern equine encephalitis. Jour. Infect. Dis. 105(3):293–296.

SCHERER, W. F. and SMITH, R. P. J. 1960. In vitro studies on the sites of Japanese encephalitis virus multiplication in the heron, an important natural host in Japan. Amer. Jour. Trop. Med. and Hyg. 9(1):50–55.

FILARIASIS

ANDERSON, R. O. 1959. The taxonomy of *Dipetalonema spirocauda* (Leidy, 1858) n. comb. (= *Skrjabinaria spirocauda*) and *Dirofilaria roemeri* (Linstow, 1905) n. comb. (= *Dipetalonema roemeri*). Canad. Jour. Zool. 37(4):481–493.

BERTRAM, D. S. 1958. Experimental epidemiology with the filarioid infection of cotton rats. Internatl. Cong. Ent. Proc. 10(3):503–506.

———. 1959. Host-parasite relationships in the arthropod-borne filarioid infections. Internatl. Cong. Zool. Proc. 15:689–690.

BURTON, G. 1959. Studies on the bionomics of mosquito vectors which transmit filariasis in India. I. Attachment of *Mansonia uniformis* larvae to host plants occurring in *Pistia* tanks in Kerala, South India. Indian Jour. Malariol. 13(2/3):75–115.

CHU, S. F., SUN, C. H. and CHEN, H. H. 1959. Observations on filariasis in Chung Hua Hsien, Kwangtung. Acta Microbiol. Sinica 7(1/2): 25–31. In Chin., Engl. Sum.

EDESON, J. F. B. 1959. Studies on filariasis in Malaya: The periodicity of the microfilariae of *Brugia malayi* and *B. pahangi* in animals. Ann. Trop. Med. and Parasitol. 53(4):381–387.

———. 1959. Studies on filariasis in Malaya: The accuracy of blood surveys. Ann. Trop. Med. and Parasitol. 53(4):388–393.

——— and LAING, A. B. G. 1959. Studies on filariasis in Malaya: The effect of diethylcarbamazine on *Brugia malayi* and *B. pahngi* in domestic cats. Ann. Trop. Med. and Parasitol. 53(4): 394–399.

GUN DZYAN-CHZHAN. 1960. A new carrier of human filariasis in China. Med. Parazit. i Parazit. Bolezni 29(1):98–101. In Rus., Engl. Sum. [*Aedes togoi* possible vector.]

HAWKING, F. 1959. *Dirofilaria magnilarvatum* Price, 1959 (Nematoda: Filaroidea) from *Macaca irus* Cuvier. III. The behavior of the microfilariae in the mammalian host. Jour. Parasitol. 45(5): 511–512.

HOBSON, H. P. 1959. Angiocardiography in canine dirofilariasis. I. Preliminary studies. Amer. Vet. Med. Assoc. Jour. 135(11):537–544.

IYENGAR, M. O. T. 1959. Annotated bibliography of filariasis and elephantiasis. Part 4—Treatment. South Pacific Comm. Noumea, New Caledonia. Tech. Paper No. 124, 177 pp.

———. 1959. Filariasis in Netherlands New Guinea. South Pacific Comm. Noumea, New Caledonia. Tech. Inform. Cir. 34, 8 pp.

———, ROOK, H., DE and DIJK, W. J. O. M., VAN. 1959. Interruption of transmission of *Anopheles*-borne filariasis by indoor residual spraying in Netherlands New Guinea. Trop. and Geog. Med. 11(3):287–290.

JORDAN, P. 1959. The treatment of bancroftian elephantiasis and observations on hyaluronidase. Jour. Trop. Med. and Hyg. (London) 62(12): 286–289.

MARCH, H. N., LAIGRET, J., KESEL, J. F. and BAMBRIDGE, B. 1960. Reduction in the prevalence of clinical filariasis in Tahiti following adoption of a control program. Amer. Jour. Trop. Med. and Hyg. 9(2):180–184.

NELSON, G. S. 1959. The identification of infective filarial larvae in mosquitoes: With a note on the species found in "wild" mosquitoes on the Kenya Coast. Jour. Helminth. 33(2/3):233–256.

PRICE, D. L. 1959. *Dirofilaria magnilarvatum* n. sp. (Nematoda: Filaroidea) from *Macaca irus* Cuvier. I. Description of the adult filarial worms. Jour. Parasitol. 45(5):499–504.

SENEVIRATNA, P. 1959. Studies on the family Filaroididae Schulz, 1951. Jour. Helminth. 33(2/3):123–144.

SYMES, C. B. 1959. Observations on the natural history of human filariasis in Fiji. A report to the Secretary of State for the Colonies on investigations conducted over the period 1954–1956. 126 pp.

TAYLOR, A. E. R. 1959. *Dirofilaria magnilarvatum* Price, 1959 (Nematoda: Filaroidea) from *Macaca irus* Cuvier. II. Microscopical studies on the microfilariae. Jour. Parasitol. 45(5):505–509.

WHARTON, R. H. 1959. *Dirofilaria magnilarvatum* Price, 1959 (Nematoda: Filaroidea) from *Macaca irus* Cuvier. IV. Notes on larval development in *Mansonioides* mosquitoes. Jour. Parasitol. 45(5):513–518.

WU, C. C. 1959. A report on filariasis and its mosquito vectors in Wuchang, Hupeh Province. Acta Microbiol. Sinica 7(1/2):16–24. In Chin., Engl. Sum.

MALARIA

ANTI-MALARIA CO-ORDINATION BOARD, WHO. 1960. Report of the Fourth Meeting of the Anti-Malaria Co-ordination Board of Burma, Cambodia, Laos, the Federation of Malaya, Thailand and Viet-Nam. WHO/Mal/250, 33 pp. [Kuala Lumpur, Dec. 1–4, 1959.]

ANWAR-UL-HAQ. 1959. Public cooperation in malaria. Control programme. Pakistan Jour. Health 9(2):126–130.

CENTRAL AFRICAN JOURNAL OF MEDICINE. 1960. A useful diagram illustrating the relationship of epidemiological factors in malaria. Cent. Afr. Jour. Med. 6(2):70–71.

———. 1960. Infant mortality from malaria. Cent. Afr. Jour. Med. 6(1):25.

DIAZ MARIN, J. 1959. El problema del paludismo en el continente Africano. Med. Trop. (Madrid) 33(5/6):297–308.

DOTSENKO, A. A. 1960. Sanitary hydrotechnical antimalarial works in RSFSR during postwar years (1946–1955) and their efficacy. Med. Parazit. i Parazit. Bolezni 29(1):79–82. In Rus.

DUKHANINA, N. N. 1959. Distribution of tertian malaria of long incubation in the USSR. *In* Trudy Instituta. pp. 103–136, Moscow. In Rus.

GILLES, H. M. and MCGREGOR, I. A. 1959. Studies on the significance of high serum gammaglobulin concentrations in Gambian Africans. I.—Gamma-globulin concentrations of Gambian children in the first two years of life. Ann. Trop. Med. and Parasitol. 53(4):492–500.

GÖKBERK, C. 1959. Increase in incidence of malaria cases in Adana region, Turkey, on the resistance of vector *A. sacharovi* to insecticides. Riv. di Malariol. 38(4/6):197–211.

GONGORA, J. and MCFIE, J. 1959. Malnutrition, malaria and mortality. The use of a simple questionnaire in an epidemiological study. Roy. Soc. Trop. Med. and Hyg. Trans. 53(3):238–247.

INGCO, M. F. 1958. Malaria in high altitudes in the Philippines. Dept. Health Bul. (Philippines) 30(2):35–47.

JOHNSON, C. M. 1960. Malaria. Gorgas Mem. Lab. Ann. Rpt., 1959, 86th Congress, 2nd Session, House Doc. No. 250:13–16.

LEVENSON, E. D., VINOGRADSKAYA, O. N., APTEKAR, S. A. and NETSENGEVICH, M. R. 1959. Characteristics of epidemiology of malaria in Kaliningrad Oblast. *In* Trudy Instituta. pp. 137–177, Moscow. In Rus.

PIGANIOL, G. and COUCHE, —. 1959. Considérations sur le paludisme des rapatriés. Soc. de Path. Exot. Bul. 52(4):497–503.

PROKOPENKO, L. I. 1959. Epidemiology of "a lightning-like" form of malaria. *In* Trudy Instituta. pp. 80–102, Moscow. In Rus.

RADACOVICI, E. and COWORKERS. 1959. A study on the course of endemic malaria in the Hydrographic Basin of the Arges River and its tributaries. Microbiol., Parazitol., Epidemiol. (Bucharest) 4(2):149–162. In Roum.

SALITNERNIK, Z. (Director). 1958. Israel Ministry of Health. Antimalarial Division. A review of the State's ten years 1948–1957. 47 pp.

SANDOSHAM, A. 1959. Malariology with special reference to Malaya. 327 pp., London.

SARIKIAN, S. YA. and ZHUKOVA, T. A. 1959. Organization of control of malaria in regions of low malaria morbidity. *In* Trudy Instituta. pp. 215–224, Moscow. In Rus.

SERGIEV, P. G. 1960. The epidemiology of disappearing malaria. I. The epidemiology of malaria in the late stage of eradication in countries with temperate and sub-tropical climates. II. The importance of asymptomatic parasite carriers in malaria eradication. WHO/Mal/252, 9 pp.; WHO/Mal/253, 6 pp.

SPITZ, A. J. W. 1959. Malaria infection of the placenta and its influence on the incidence of prematurity in eastern Nigeria. WHO Bul. 21(2) 242–244.

SWAROOP, S. 1959. Statistical consideration and methodology in malaria eradication. Part 1 Statistical considerations. Part 2: Statistical methodology. WHO/Mal/240, WHO/HS/102. Pt. 1 205 pp.; Pt. 2, 202 pp.

TOUMANOFF, C. 1959. Étude sur l'anophélism dans la région du Rio-Nunez (Basse-Guinée) Méd. Trop. (Marseilles). 19(3):294–311.

TRINIDAD GOVERNMENT. 1959. Annual repor of the Malaria Division, Health Department, Trinidad and Tobago, 1958. 49 pp., Port of Spain B.W.I.

WORLD HEALTH ORGANIZATION. 1960. Malari information. WHO Mal/Inform/55, 14 pp [Future planning in malaria eradication, organophosphorus insecticides, new pilot project in North Cameroons et al.]

———. 1960. Malaria information. WHO Mal/Inform/56, 14 pp. [Problems in Philippines evaluation of Mexican malaria eradication campaign, features of Costa Rica's malaria eradicatio plan, induced malaria.]

———. 1960. Malaria information. WHO Mal/Inform/57, 14 pp. [Meeting of scientific group on malaria research, 10th Expt. Comm. o Insecticides, financial contributions for malari eradication, et al.]

Malaria—Eradication Projects

ANDRIS, V. G. 1960. Changes in the epidemiology of malaria in the Agdzhabedinsk region o Azerbaidzhan SSR and prospects of complet eradication of malaria. Med. Parazit. i Parazit Bolezni 29(1):76–79. In Rus.

BUSTAMANTE, F. M., DE. 1959. Considerações sôbre certos problemas especiais relacionados com a erradicação da malária no Brasil. Rev. Brasil de Malariol. 11(1):9–17.

DA SILVA, O. J. 1959. Progress of malari eradication campaign in the Americas. N. J Mosquito Extermin. Assoc. Proc. 46:57–61.

GRAY, H. F. 1960. An analysis of the eradication concept. Mosquito News 20(1):14–23.

MORIN, H. G. S. 1959. Comment entendr l'éradication du paludisme? Soc. de Path. Exot Bul. 52(4):485–497.

PRIETO, I. M., MARQUEZ ESCOBEDO, M. B. and VARGAS, L. 1959. La erradicacion del paludismo en Mexico. Sec. de Salubridad y Asis. Com Nac. para la Erad. del Paludismo. 13 pp.

SARIKIAN, S. YA. 1959. Eradication of malari in the zone of the Volga-Don junction. *In* Trudy Instituta. pp. 178–214, Moscow. In Rus.

SHAMASASTRY, H. and NARAYANA IYENGAR, M. A 1959. First year's results of a pilot study of malaria surveillance measures in Mysore State, India Indian Jour. Malariol. 13(1):35–65.

Malaria—Plasmodia

BANO, L. 1959. A cytological study of early oocysts of seven species of *Plasmodium* and the

ccurrence of post-zygotic meiosis. Parasitology 9(3/4):559–585.

BRAY, R. S., BURGESS, R. W., FOX, R. M. and MILLER, M. J. 1959. Effect of pyrimethamine pon sporogony and pre-erythrocytic schizogony f *Laverania falciparum*. WHO Bul. 21(2):233–38. [*Plasmodium falciparum*.]

COWPER, S. G. 1959. An amending note on he transmission of *Plasmodium berghei* from mmunized rats to subinoculated mice. Ann. Trop. Med. and Parasitol. 53(4):507–508.

DEMINA, N. A. 1959. Influence of diurnal hythm of the host on the periodicity of *P. elictum* reproduction. *In* Trudy Instituta. pp. 28–79, Moscow. In Rus.

RAFFAELE, G. 1959. Commento alle ricerche sulla fase esoeritrocitica dei parassiti malarici. Riv. di Malariol. 38(4/6):159–196.

VASINA, S. G. 1959. Development of tissue forms of *Plasmodium gallinaceum* in the epithelial cells of the hen. *In* Trudy Instituta. pp. 7–13, Moscow. In Rus.

Malaria—Therapeutics and Antimalarials

BEUTLER, E. 1959. The hemolytic effect of a primaquine and related compounds: A review. Blood 14(2):103–139.

BRUCE-CHWATT, L. J. 1960. Determinación de la excreción de drogas antimaláricas en la orina en programas de erradicación quimioterapéutica en gran escala. Bol. Ofic. Sanit. Panamer. 48(2): 151–159.

CAYLA, J. 1958. La lutte antipaludique en Turquie. Bul. Inform. Ministère Santé Publique et Population. (Paris) No. 1/2:7–13.

DEMINA, N. A. 1959. Study of prophylactic and therapeutic properties of sera of animals immunized against malaria in relation to the transfer of immunity of the mother to her descendants. *In* Trudy Instituta. pp. 14–27, Moscow. In Rus.

GILROY, A. B. 1959. The role of drugs in malaria eradication in South-East Asia. Indian Jour. Malariol. 13(1):1–5.

NEGULICI, E. and COWORKERS. 1959. Studies on the sporontocidal effect of single doses of pyrimethamine—alone or associated with chloroquine—in *P. vivax* and *P. falciparum* malaria. WHO/Mal/248, 8 pp.

RICOSSÉ, J., BAILLY-CHOUMARA, H., ADAM, J. P. and HAMON, J. 1959. Résultats d'une expérimentation de chimioprophylaxie par la pyriméthamine dans la zone pilote de lutte antipaludique de Bobo-Dioulasso. Soc. de Path. Exot. Bul. 52(4):516–535.

YELLOW FEVER

CHRISTOPHERS, S. R. 1960. *Aedes aegypti* (L.). The yellow fever mosquito: Its life history, bionomics and structure. 738 pp., Cambridge, England.

GALINDO, P. and RODANICHE, E. DE. 1960. Ecology of yellow fever and other arthropod-borne viruses. Gorgas Mem. Lab. Ann. Rpt. 1959, 86th Congress, 2nd Session, House Doc. No. 250:1–4.

KERR, J. A., ROCA-GARCIA, M. and BUGHER, J. C. 1960. Naturally acquired yellow fever immunity in Muzo, Colombia. Amer. Jour. Trop. Med. and Hyg. 9(1):18–28.

PINTO SEVERO, O. 1959. Some aspects of the *Aedes aegypti* eradication in the Western Hemisphere. N. J. Mosquito Extermin. Assoc. Proc. 46:44–51.

WOODALL, J. P. 1959. Studies on *Aedes apicoargenteus* and yellow fever virus. East Afr. Virus Res. Inst. Rpt. 9:21–22.

OTHER DISEASES

AITKEN, T. H. G. 1960. A survey of Trinidadian arthropods for natural virus infections (August, 1953 to December, 1958). Mosquito News 20(1):1–10.

ANDERSON, C. R., AITKEN, T. H. G., SPENCE, L. P. and DOWNS, W. G. 1960. Kairi virus, a new virus from Trinidadian forest mosquitoes. Amer. Jour. Trop. Med. and Hyg. 9(1):70–72.

ANDERSON, C. R., SPENCE, L. P., DOWNS, W. G. and AITKEN, T. H. G. 1960. Manzanilla virus: a new virus isolated from the blood of a howler monkey in Trinidad, W. I. Amer. Jour. Trop. Med. and Hyg. 9(1):78–80.

CASALS, J. and WHITMAN, L. 1960. A new antigenic group of arthropod-borne viruses. The Bunyamwera group. Amer. Jour. Trop. Med. and Hyg. 9(1):73–77.

GILLETT, J. D. 1959. East African Virus Institute, Entebbe. Report No. 9, 1958–59, 49 pp.

HADDOW, A. J. and COWORKERS. 1959. Attempted virus isolation from mosquitoes. East Afr. Virus Res. Inst. Rpt. 9:11.

KOKERNOT, R. H., SMITHBURN, K. C., PATERSON, H. E. and MCINTOSH, B. M. 1960. Isolation of Germiston virus, a hitherto unknown agent from culicine mosquitoes, and a report on infection in two laboratory workers. Amer. Jour. Trop. Med. and Hyg. 9(1):62–69. [Strains isolated from *Culex theileri* and *C. rubinotus*.]

ROCKEFELLER FOUNDATION VIRUS LABORATORIES, NEW YORK. 1960. Annual report for year 1959. Rockefeller Inst. 80 pp.

TAYLOR, R. M. 1959. Studies on the ecology of arthropod-borne (arbor) viruses. Yale Jour. Biol. and Med. 32(1):16–22.

LIGHT TRAP STUDIES

CORBET, P. S. 1959. Catches at mercury-vapour light in Mpanga Forest. East Afr. Virus Res. Inst. Rpt. 9:33–34.

——— and HADDOW, A. J. 1959. Catches of mosquitoes in mercury-vapour light traps. East Afr. Virus Res. Inst. Rpt. 9:34.

DU CHANOIS, F. R. 1959. Relative periodic attractivity of light traps to adult mosquitoes as an index to mosquito annoyance intensity. N. J. Mosquito Extermin. Assoc. Proc. 46:170–180.

HAUFE, W. O. and BURGESS, L. 1960. Design and efficiency of mosquito traps based on visual response to patterns. Canad. Ent. 102(2):124–140.

LITERATURE REFERENCES AND REVIEWS

DUKHANINA, N. N. 1960. Native literature on medical parasitology and parasitic diseases published in 1959. Med. Parazit. i Parazit. Bolezni 29(1):107–124. In Rus. [Includes mosquitoes and malaria.]

SOLLERS, H. 1959. 1958 world resumé of mosquito activities. N. J. Mosquito Extermin. Assoc. Proc. 46:16–43.

———. 1960. References to literature of interest to mosquito workers and malariologists. Mosquito News 20(1):74–81.

WILCOCKS, C. 1960. Summary of recent abstracts. II. Yellow fever. III. Malaria. Trop. Dis. Bul. 57(2):93–96, 57(3):205–211.

BIOGRAPHY AND HISTORY

HACKETT, L. W. 1960. Once upon a time. Amer. Jour. Trop. Med. and Hyg. 9(2):105–115.

IDELCHIK, KH. I. 1959. An abstract from the biography of E. I. Martsinovsky. Med. Parazit. i Parazit. Bolezni 28(6):646–648.

PUBLIC RELATIONS

GEIB, A. F. 1960. Two-way radio aids mosquito abatement district. Mosquito News 20(1): 31–33.

PRATT, H. D. 1959. Audiovisual aids of interest to mosquito control workers. N. J. Mosquito Extermin. Assoc. Proc. 46:121–124.

SUBJECTS NOT COVERED BY OTHER HEADINGS

BEKLEMISCHEV, W. N. and RASHINA, M. G. (Editors). 1959. Trudy Instituta. 629 pp., Moscow. [Pub. by Martsinovsky Inst. of Med. Parazit. and Trop. Med.] In Rus.

CORBET, P. S. 1959. Surveys of mosquito larvae in Mpanga Forest. East Afr. Virus Res. Inst. Rpt. 9:29–30.

DESPLAINES VALLEY MOSQUITO ABATEMENT DISTRICT. 1960. Thirty-second annual report 1959. 18 pp., Lyons, Illinois.

HOCKING, B. 1960. Northern biting flies. Ann. Rev. of Entomology Vol. 5:135–152. [Includes mosquitoes.]

KIRKLAND, C. J. 1959. Address by the president. N. J. Mosquito Extermin. Assoc. Proc. 46:6–7.

PAKISTAN COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH. 1959. Quinquennial report 1953–1958. 224 pp., Karachi. [Includes antimalarials.]

WEST, A. S. and HUDSON, A. 1959. Reactions to insect bites. N. J. Mosquito Extermin. Assoc. Proc. 46:140–148.

ERRATA

Under section on Biology and Ecology, Mosquito News 19(1):38 change pages under Goma to read: 437–448; in 19(4):298 under section on Filariasis change pages under Manson-Bahr 62(7) to read: 62(7):160–173.

ADVERTISING RATES

FOR

Mosquito News

	1 issue	4 issues
Full-Page	**$50.00**	**$180.00**
Half-Page	**$30.00**	**$108.00**
Professional Card	**$6.00**	**$20.00**

Preferential Positions — $5.00 an issue extra

1. Facing Front Cover **2. Facing First Article**

3. Facing Back Cover

(Type setting and cuts furnished by Association are extra)

For Information Write

FRANCIS P. CREADON

Desplaines Valley Mosq. Abatement Dist.

8130 Ogden Avenue **Lyons, Ill.**